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UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

1731

WASHINGTON, D. C. 726 JUNE 8, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

NATAL GRASS: A SOUTHERN PERENNIAL HAY CROP.

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INTRODUCTION.

Natal grass[1] is a South African plant which has been known in Florida for a long time. In recent years it has become popular on the sandy soils of the State, and to some extent along the Gulf coast westward into southern Texas. It is a perennial, but does not survive the winter where the temperature falls much below freezing. It is usually treated as an annual crop.

In the United States it is now cultivated more extensively in Florida than elsewhere. In that State estimates of its acreage in 1915 were secured from growers, from boards of trade, and through field observation by agents of the Department of Agriculture. These estimates indicate that Lake County has fully 10,000 acres, probably a larger acreage than any other county, though Marion County has nearly as much. Sumter County has about 3,000 acres, and Pasco County probably an equal area. Hillsborough and De Soto Counties have over 2,000 acres each, and many other counties have smaller areas. The acreage is being extended very rapidly in many sections of the State where the soil is suited to its growth. Farther west

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[1] *Tricholaena rosea* Nees.

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along the Gulf coast Natal grass succeeds well, but has not yet been extensively planted. The accompanying map (fig. 1) shows the regions in the United States where this grass has been found of great value and other regions where it should be more thoroughly tested. It is grown very extensively in Australia, and it is from that country that most of the seed has been imported.

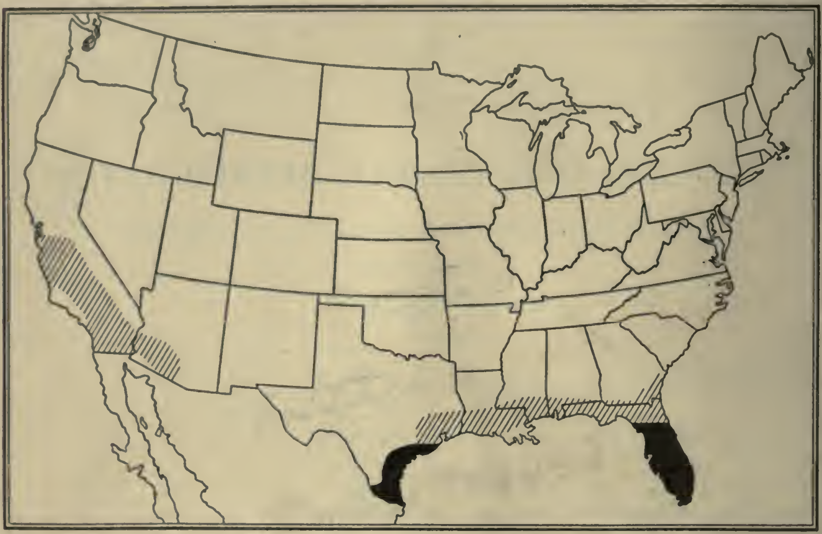

FIG. 1.—Outline map of the United States, indicating the regions to which Natal grass is adapted. The black areas show where it succeeds best and the shaded areas where it should be tested.

While it can be grown as a summer annual as far north as Washington, D. C., it is not likely to become of much importance as a field crop except in the extreme South.

DESCRIPTION OF NATAL GRASS.

When a single plant of Natal grass is allowed abundant room it will form a large tuft, sometimes 3 to 4 feet in diameter. The lower branches soon become decumbent, while the central stems are more nearly erect. When planted closely, however, the tufts are much smaller, often making only a few stems, and those nearly erect. The stems are slender, 3 to 4 feet high, and well covered with leaves, which are so nearly erect that few are lost in mowing the hay.

The seeds are produced in large clusters of about the size and shape of a panicle of oats, as shown in figure 2. In most cases the seed clusters are bright red or rosy crimson in color, and for that reason the grass has sometimes been called redtop, Australian redtop, and Hawaiian redtop. It is, however, very different from the common northern grass known as redtop. For this reason the name Natal grass, which indicates the country of which it is a native, is more appropriate and distinctive and is the one now in most common use.

The root system is unusually strong, the roots being numerous and penetrating very deeply into the soil, so that they reach permanent moisture in the subsoil and enable the plants to make a continuous growth even in very dry weather. These roots are very slender and decay quickly, so that they do not interfere with the planting of other crops immediately after the ground has been plowed.

While the grass is very persistent with annual plowings, and fairly so without plowing, it never becomes a troublesome weed. The plants are killed by a single plowing, and by keeping the land cultivated in other crops through the whole of a single season all the seeds in the ground will have germinated and the young plants will be killed by the cultivation.

Natal grass can be cultivated profitably only when used for the production of hay or of seed or both. Its greatest value is for making hay, for which it is the best grass yet found for the well-drained sandy soils in Florida. The stems and leaves are very slender and cure into hay easily and quickly. The seed now finds a ready market at a fair price.

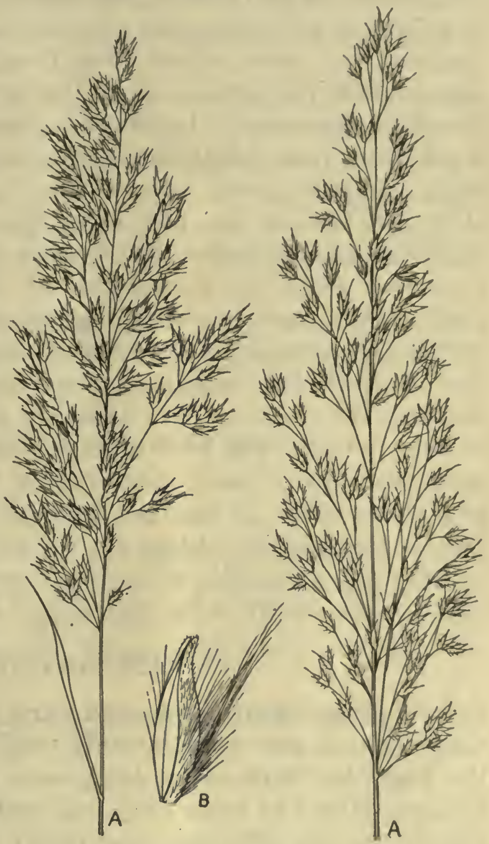

Fig. 2.—Seed heads of Natal grass (*A*, *A*) and a seed (*B*) (greatly enlarged).

HISTORY AND INTRODUCTION INTO THE UNITED STATES.

Natal grass was first described by Nees in 1835,[1] from specimens collected in South Africa. Its attractive appearance led to its being cultivated as an ornamental plant, and it was grown in the United States for that purpose as early as 1866, as is shown by specimens still preserved in the National Herbarium. It was grown as a forage plant in the trial gardens of the Department of Agriculture in 1878. A recent letter from T. A. Carroll, now of Jacksonville, Fla., states that he found it growing on a trash pile at Reddick, Fla., in 1875, and by 1894 it was abundant in that region. In 1884 seed was sent by a naval officer from Brazil to an orange grower near Altamonte Springs, Fla., and by 1890 it had spread a few miles in all directions from there. In 1891 it was received by the Department of Agriculture from Natal, South Africa, and from Queensland, Australia; in 1892 it was secured from India, and in 1894 from the Hawaiian Islands. In 1892 it was grown at the Florida Agricultural Experiment Station, then located at Lake City, from seed grown from that which the Department of Agriculture had received the previous year, and it soon spread in several parts of Florida. In 1906 the Department of Agriculture obtained a large quantity of seed from Reddick, Fla., and distributed it during the following year. At that time the grass was very abundant there over an area of perhaps 15 miles in length and 6 to 8 miles in width. Several persons who had lived there many years stated that it had become well established as early as 1884. At the time this seed was gathered a considerable area of the grass was being cut for hay for local use. Within the last five years the cultivation of the grass for hay has become very extensive, especially in the central part of the State of Florida.

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[1] Nees von Esenbeck, C. G. D. Annotationes botanicae ex Indice seminum hort. bot. Vratislaviensis, anno 1835. *In* Ann. Sci. Nat. Bot., s. 2, t. 6, p. 105. August, 1836. Original not available.

The description is given also in Linnaea, Bd. 11, Lit. Ber., p. 129, 1837; also in Nees von Esenbeck, C. G. D., Florae Africae Australioris . . . I. Gramineae, p. 17. Glogaviae, 1841.

CLIMATIC ADAPTATIONS.

Natal grass requires a long and warm season for its growth. Being a perennial, it grows continuously until checked by cold weather, so the longer the warm season the greater will be its period of growth. It is not injured by moderately cool weather, but its growth is always stopped by the first frost, and nearly all the plants are killed by even a slight freezing of the ground. Heavy freezing when the ground is damp not only kills the plants, but it also kills many of the scattered seeds and so prevents the reseeding of the ground. The cultivation of this grass is not recommended where heavy winter freezes occur, or even where light freezes are frequent.

Natal grass makes its principal growth in middle and late summer, and most of that now cultivated in Florida is grown in rotation with some winter or early-spring crop.

SOIL PREFERENCES.

Natal grass is like any other plant in that it makes its best growth on the richest soil. Fertilizers are seldom used directly on the grass.

They are not needed for making a good crop on land which has been newly cleared, as such soil always produces a heavy yield. Older fields are usually well fertilized in the fall for the growing of some winter crop, and the residue of that fertilizer is sufficient to make a good growth of the grass during the following seasons. When any special fertilizer is used on the grass it should be largely nitrogenous, cottonseed meal or nitrate of soda being the materials most commonly used.

The best soil for the grass is one which is sandy and well drained. On such soils it makes a better growth than any other grass and reseeds itself freely. Excellent crops of Natal grass have been grown on muck soils in various sections of Florida, but it is doubtful whether it will be as profitable there for either hay or grazing as grasses which make a heavier growth, like Para grass and Rhodes grass.

While Natal grass grows well on clayey soils, there is yet little experience to show whether it will reseed the ground as thoroughly on such soils as on those which are more sandy.

PREPARATION OF THE SEED BED.

No special preparation of the ground is necessary before sowing the seed except that the surface should be made as fine, mellow, and even as possible, as for seeds of all hay grasses. The field should be made so smooth that a mowing machine can be used without trouble. It costs far more to run a mowing machine over a field which is rough and uneven than it does to harrow the same field until all bumps are leveled and all holes filled.

If the soil is heavy or cloddy the harrowing should be much more thorough than where it is light and sandy. If the field has been used for some crop which was grown in rows it should be disked and harrowed until no trace of the rows can be seen. All stumps should be removed, not only for the sake of securing additional ground on which the grass may grow, but also to avoid injuries to the mowing machine and other implements used in harvesting the crop. It pays well to put the ground in the best possible condition before the seed is sown.

TIME OF SEEDING.

In central and southern Florida seeding may be done at any time during the year, though spring is the favorite season and the only season in which it should be done farther north. In southern Florida many growers prefer to sow in September or October. Sown at that time the seeds germinate quickly and the young plants go through the winter with little or no loss and give a much earlier cutting of hay than plants from seed sown in the spring.

When the ground is not occupied by a winter crop it may be plowed or disked in late winter or early spring, fertilized if necessary, and the seed sown. Such seeding will give a good cutting of hay in May or June, and two or three cuttings later in the season.

METHODS AND RATE OF SEEDING.

The seed is always broadcasted, as it will not feed through a drill evenly. The seeds are very hairy and usually stick together in large bunches when dry, so it is well to dampen and roll them in soil or wood ashes before sowing. When treated in this way they remain separate and it is much easier to secure an even distribution over the ground. After sowing, a plank dragging or a rolling is all that is necessary to cover the seeds. Many planters think it better to leave the covering wholly to the rains. The seed should never be covered deeply, and therefore it is important that the surface of the ground be made fine and smooth before the seed is sown.

In sections where the grass is abundant it spreads naturally to cultivated fields, the seeds being carried by the wind, the feet of animals, farm implements, and in other ways. When a field is once covered by a good stand of the grass, no attention need be given to subsequent seeding, as the grass will volunteer each year.

The quantity of seed to be used will vary with its quality, with the season when sown, and the time when a full crop of hay is expected. When the seed is of good quality and the sowing is done in early spring while the ground is still occupied with oats, potatoes, or some other winter crop and no hay crop is expected until late summer, the seeding may be very light, only 2 or 3 pounds per acre. If not done until later in the season it should be much heavier, 8 to 10 pounds per acre, so as to secure a full stand as soon as possible.

When the ground is occupied by some other crop in the spring, it is a frequent practice to set out young plants, placing them 8 to 10 feet apart, instead of using seed. Such plants ripen a crop of seed earlier than those from seeds planted at the same time and so give the ground a full reseeding earlier. Setting plants is more troublesome and expensive than the planting of seed and is not recommended except where a full crop of hay is desired as promptly as possible after removing the other crop. The few plants needed can always be set so that they will not interfere with the growing crop. They cost only the labor of planting, and their use hastens the securing of a full stand.

ROTATION AND MANAGEMENT.

A common practice in growing Natal grass is to plow the ground after the last cutting has been made in the fall and then plant the land to oats or some winter truck crop. After the winter crop is removed in the spring, the land is given a shallow plowing or disking and is harrowed until smooth. When treated in this way no reseeding is necessary, as the fall plowing buries the scattered seed in the ground, where it remains in good condition through the winter, while the spring plowing or disking brings it back near the surface, where it germinates quickly. On fields treated in this way the first cutting for hay can be made about two months after the spring disking, and later cuttings from six to eight weeks apart. If the land be plowed deep in the fall and not replowed in the spring, most of the seeds will be so deep in the ground that they can not germinate, and the stand of grass will be thin and uneven.

When a truck crop, like melons, is not planted until early spring the grass crops will be later in maturing. Where such truck crops are grown, a little care in cultivation will leave the ground sufficiently smooth for the use of a mowing machine, and the first cutting for hay can be secured about two months after the last cultivation. In this case, the several cultivations of the truck crop bring sufficient seed near the surface of the ground to insure a good stand of the grass.

Where the ground is well set with the grass and it is not plowed in the fall, it will give a cutting in the spring much earlier than when plowed in fall and spring, and usually four or five cuttings may be secured during the season, though the total yield for the year will be about the same as when plowed. After the second or third year without plowing, other grasses and weeds begin to come in, making the quality of the hay inferior and decreasing the yield. One objection to leaving the ground without plowing in the fall is that in the spring the plants start into growth very unevenly, so that by the time there is enough of the grass to pay for cutting, some of the stems will be old and dry, while others will be only partly grown. When plowed in the fall and disked in the spring the plants start much more evenly and the first cutting is of a decidedly better quality, as is shown in figure 3.

It has not been found advisable to sow Natal grass with cowpeas, beggarweed, or any other forage crop yet tested for the purpose, as they do not mature at the same time. Whatever other crop has been used for mixing with Natal grass, its growth has been so small before the Natal grass is ready for cutting that there is little or no increase in the total yield of the crop and no improvement in the quality of the hay.

When a suitable field has once been seeded it will continue to produce the grass for many years, and perhaps indefinitely, if the land is cultivated occasionally, so as to kill out broom sedge and other weedy grasses and to break up the crust.

HARVESTING THE HAY.

The mowing of Natal grass should begin as soon as a considerable part of the seed begins to ripen. If the weather should be unfavorable at that time it can stand several days without great injury, as it is making a continuous growth of new shoots. When the cutting is delayed too long the quality of the hay is injured by the shattering of the seeds and by the drying up and breaking off of the older stems. The greatest loss from delaying the cuttings too long is the consequent postponement of the subsequent cuttings. To secure the greatest yield during the year and to make hay of the highest quality, all of the earlier cuttings should be made as soon as the grass is in proper condition, though the last cutting may be delayed until a few days before frost is expected, as the grass is growing rapidly at that time and the late cutting insures a good supply of seed on the ground for the following spring.

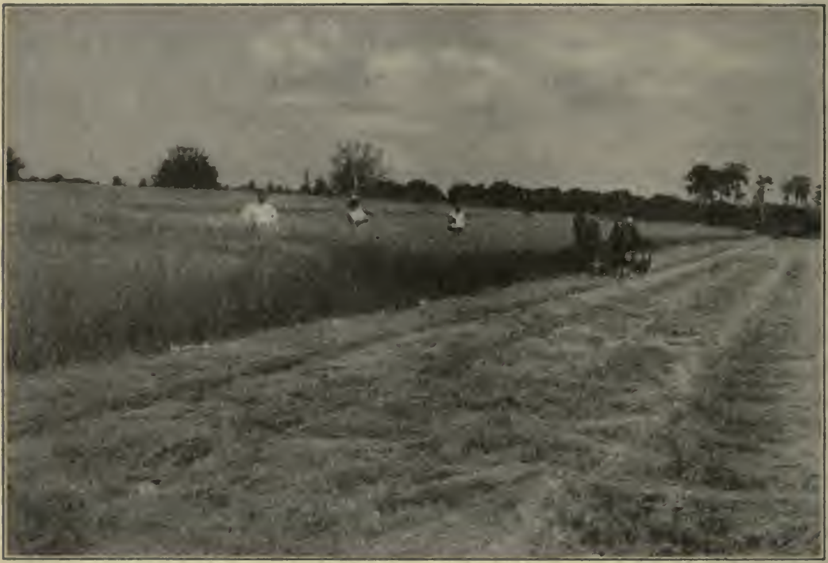

FIG. 3.—A field of Natal grass in Florida.

The grass dries so quickly that it should be allowed to lie on the ground only a short time. Unnecessarily long exposure bleaches the hay and makes it less palatable, less nutritious, and less salable. The best hay is that which is cured in the shortest time and with the least exposure to the weather. Exposure to rain bleaches and injures the hay seriously, and even exposure to heavy dews deadens the color and makes the hay less attractive in appearance. One can usually be reasonably sure of the weather several hours in advance and choose a time for cutting when the hay can at least be cured sufficiently to put it in the cock before it is wet by rain or dew.

When the weather is favorable for curing, it is best to mow in the morning, from the time the dew is off until noon, and then windrow and cock in the afternoon. The hay should remain in the cock until thoroughly field cured. The time required for this field curing will depend on the condition of the weather. If very favorable it may be safe to haul it to the barn after it has been in the cocks 36 to 48 hours, but a longer time is often necessary.

Field curing may be regarded as completed when the stems are so dry that they will break when a small wisp of the hay is twisted tightly, when it does not feel cool if pressed to the cheek, and when stirring it slightly produces a dry rustle.

When conditions are unfavorable for drying, as in rainy, cool, or cloudy weather, the field curing requires a much longer time and is often unsatisfactory.

With all the judgment which the grower may use, some hay will occasionally be caught by rain, and it then requires special care to cure it thoroughly. If it rains on the hay soon after it is cut little harm will be done, but the injury will be greater if the rain comes after it is partially dry. If the dry or even partly dry hay be wet with rain, it should not be touched until the surface has become thoroughly dry. If it is still in the swath it will need no attention unless the crop is very heavy, when it should be tedded or turned with a fork. If in the windrow or cock it should be opened and spread as soon as the outside has become well dried.

Much field injury from rain may be prevented by the use of hay caps for covering the cocks. These caps are made in various styles, but the one most generally liked is a piece of heavy cotton cloth 4 to 5 feet square, with a pin of heavy wire a foot in length fastened to each corner. When the cap is put in place and the pins are pushed into the cock to prevent it from being blown off, the hay will stand a heavy rain with very little injury. The hay should not be put into the barn or the stack until it is so dry that there will be no danger from heating and molding, and when the weather is not very warm and dry it is not safe to bale it until at least a week after it is cut. In case it must be taken to the barn while still slightly damp, a dressing of salt, about 5 pounds per ton, or a light sprinkling of freshly slaked lime will aid in its preservation.

The field curing should be as thorough as the weather will permit, after which the hay should be hauled to the barn and the final curing completed there.

At present a large part of the Natal grass hay is put in stacks when hauled from the field. In many cases this can not be avoided, but with the frequent and heavy rains which occur in Florida it is much safer to store it in a barn or under a shed. When stacked, there is always considerable loss from leaching and bleaching on the outside of the stack, a loss which may be almost wholly prevented when the hay is protected from the weather. The sweating and final curing are much more even when completed in a mow, and so a better quality of hay is secured than is possible from an exposed stack.[1]

The hay should remain in the mow until it goes through a sweat, as this develops a sweeter aroma in the hay and makes it safe from heating and molding in the bale. The degree of heat developed in this sweating will depend very largely on the amount of moisture in the hay. If the hay is put in the mow before it is well air cured, the heat may be excessive and the hay discolored. If it is only moderately browned its actual feeding value is injured very little, though the hay is less readily salable.

In humid regions like Florida it is never safe to bale hay direct from the field or within a day or two after cutting, as is sometimes done in the dry climate of the West. If hay be baled before it has gone through the sweating process, it is always liable to sweat in the bale and perhaps become moldy and worthless.

While it may appear dry and well cured there is almost sure to be moisture left in some of the stems, especially in the joints. This moisture is often sufficient to cause heating in the bale, and when the hay reaches the market it will be found so damaged as to be classed as of very low grade.

Natal grass hay is of such recent introduction that it has not yet secured a standing in the general markets. With proper care in curing and handling it will probably rank with any other good hay in popular favor and bring an equal price on the market; but the hay can never establish its proper reputation unless great care is taken that none is offered except that which is bright in color and well cured. No hay which is not strictly of high quality should ever be placed on the outside market. If it is off color or inferior in any way it should not be shipped, but kept for home use and the local market.

YIELD OF HAY.

The average yield of Natal grass hay is 2½ to 3 tons per acre, or about three-fourths of a ton for each cutting. Double those quantities are sometimes secured where conditions are unusually favorable. When the ground is plowed in the fall and disked in the spring, three mowings are usually secured; while if not plowed or disked, four or five mowings are made, though the total yield in both cases is about the same.

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[1] For further details in regard to the drying and curing of hay, see Piper, C. V., McClure, H. B., and Carrier, Lyman, "Growing hay in the South for market," U. S. Dept. Agr. Farmers' Bull. 677, 22 p., 10 fig. 1915.

A report of the Florida Agricultural Experiment Station[1] says, in writing of this grass:

> The seed was sown in drills one foot apart on May 1 and 2, 1908. Soil and weather conditions were favorable at this time, and a good stand was obtained. Ninety days after planting the crop was ready to be cut for hay; but since it was our desire to obtain as much seed as possible, it was not cut until the seed was ripe. A good crop of seed was gathered by hand from August 10 to 15. The grass was cut for hay on August 18, and gave a yield of 3,833 pounds of field-cured hay per acre. About November 10 a second crop of seed was gathered, and a second crop of hay was cut November 19, giving a yield of 1,417 pounds of field-cured hay per acre. The total yield for the season was 5,250 pounds per acre, or 2.6 tons. Natal grass is without doubt a most promising crop for Florida farmers. With favorable soil and moisture conditions it is believed that a yield of three or four tons per acre can be expected.

It should be noted that the results reported above were secured at Gainesville, Fla., which is somewhat north of the best Natal grass region, and that the main object in growing the grass was to secure seed. Allowing it to mature two good crops of seed undoubtedly decreased the yield of hay very materially.

QUALITY OF THE HAY.

Good Natal grass hay is an excellent feed. The stems and leaves are not tough, are very palatable, and are eaten without waste. The stems are so slender that the hay makes an attractive-looking bale and so sells well on the market. The commercial use of the hay has been developed in the last few years, and wherever offere dit usually brings the same price as timothy, though in the Tampa market it sells even higher. For many years timothy has been the standard of excellence for a market hay, and any hay which can compete with it successfully must have many desirable qualities. Natal hay is easily cured, is richer in protein than timothy, sells well on the market, is eaten well by stock, and therefore is able to compete with timothy in all regions where it can be grown.

It is a well-established fact that when a grass is cut while young it contains a higher proportion of protein, the most desirable element in a food, than the same grass cut after it becomes older.

Natal grass makes a constant growth, continuing to develop new stems through the entire season, so that each cutting contains a very considerable proportion of young shoots with the more mature stems. Grasses which give only a single annual cutting usually mature evenly and are not cut until most of the stems and leaves are fairly well matured; consequently, they contain a smaller proportion of protein than they would if cut when only partly grown and therefore they have a smaller feeding value.

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[1] Scott, J. M. Report of animal industrialist. *In* Fla. Agr. Exp. Sta. Rpt. [1908]/09, p. XIX–XX. [1909.]

Table I gives the chemical analysis of Natal grass hay, based on that reported by the Florida Department of Agriculture,[1] but reduced to a water-free basis to compare with the timothy analysis, and also the average analysis of 272 samples of timothy hay, as compiled by Mr. G. L. Bidwell, of the Department of Agriculture.

TABLE I.—*Chemical analyses of Natal grass hay and timothy hay.*

Constituents (dry material).	Natal grass hay.	Timothy hay.
	Per cent.	*Per cent.*
Fiber	40.72	32.86
Ash	5.56	5.82
Protein	8.25	7.87
Nitrogen-free extract	43.47	50.40
Ether extract	1.99	3.05

The palatability of the hay is something which can not be measured, but cattle and horses seem to prefer Natal grass hay to most other kinds.

A hay which is easily cured, which is rich in protein, which sells well on the market, and which is eaten well by animals is good hay.

VALUE AS A SMOTHER CROP.

When planted on a favorable soil Natal grass makes such a vigorous growth as to choke out most other grasses and weeds. Sand spurs of several kinds are frequently a great pest on sandy soils, though where abundant they are sometimes cut for hay, making a crop of light yield and inferior quality. Sand spurs almost wholly disappear when the land is seeded to Natal grass, so that many fruit growers and truckers claim that it is worth more than it costs for that purpose alone. Sand spurs are especially troublesome in citrus groves, often being so abundant as to make work in them extremely disagreeable. The growing of Natal grass in the groves not only prevents the growth of the sand spurs, but it also gives two or three crops of excellent hay annually. Citrus groves need thorough cultivation in the spring, to stimulate them into a vigorous growth in early summer, and little cultivation in late summer, so as to reduce them to a dormant condition for the winter. The growing of Natal grass between the rows of trees accomplishes both these results very satisfactorily. The grove may be cultivated thoroughly during the early spring months, when cultivation is most needed, and in late summer, when cultivation should cease, the Natal grass takes possession of the ground, prevents the growth of sand spurs and weeds, checks the growth of the trees, and gives one or two cuttings of hay, which are so much additional profit in the cultivation of the grove. A grove treated in this manner is shown in figure 4.

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[1] Fla. Dept. Agr. Quart. Bul., v. 18, no. 1, p. 96, 1908; Fla. Agr. Exp. Sta. Rpt. [1908]/09, p. xix [1910]; Fla. Agr. Exp. Sta. Press Bul. 208, 1913.

SAVING SEED.

When new fields are to be sown with Natal grass it is sometimes difficult to secure seed which will germinate well. Good seed should show 80 to 90 per cent of germination, but many samples show less than 10 per cent. This low germination of some samples is due wholly to faulty methods of gathering and handling, as well-ripened, fresh seed which has been properly cured always germinates well. The more common custom of gathering the seed is to have cheap labor—mostly negroes and children—gather the seed by hand, the usual payment for the work being at the rate of about 10 cents a pound. Of course, the workers want to gather as many pounds as is possible in the course of the day. The ripe and the immature seed heads look very much alike, except that the ripe heads are paler in color and appear a trifle more woolly. An expert who examines the grass will see the difference at once, but the laborers usually employed for the gathering are seldom discriminating and strip the head nearest to the hand, regardless of its condition. The immature heads are more compact and more easily stripped than are those which are mature. For these reasons, a large proportion of the seed gathered by such laborers is so immature as to be nearly worthless. Seed should never be gathered until the deep-crimson color of the immature heads begins to fade to the paler red of those which are ripe and until the glossy appearance of the immature heads is obscured by the spreading hairs of those which are really ripe.

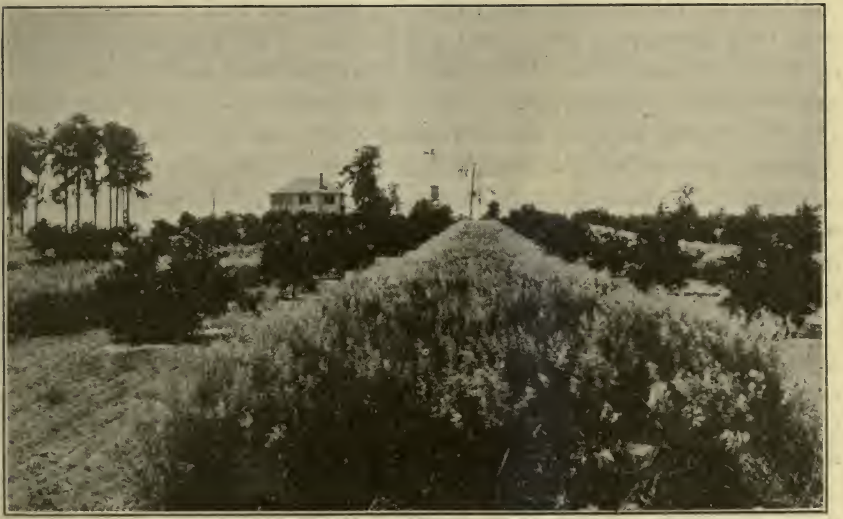

FIG. 4.—Natal grass in an orange grove.

Attempts have been made to gather the seed by machinery, using a machine similar to a suction sweeper. This gathers only the ripe seeds, which separate from the heads more easily than those which are unripe. Where the crop is fairly well matured, this machine, with one man and one horse, will gather about 10 pounds of seed per hour; but this cuts down the value of the hay crop nearly half, as the grass must be overripe for hay before the seed is ripe enough to be gathered.

Where the grass has made a good growth, the yield of seed is about 100 pounds per acre from the first growth, which can be stripped with little injury to the hay. It is claimed that a ton of seed per acre can be gathered if the crop is allowed to grow through the whole summer without being cut.

When immature seeds are gathered, they are full of moisture and heat very quickly unless spread out to dry. This heating kills many of the good seeds which may have been gathered with those which are immature. When mature seeds are gathered early in the morning while still damp with dew, they will heat and soon be killed. A closely packed sack of seed which has been gathered on one day is almost sure to become so heated as to be nearly worthless the next morning. When freshly gathered seeds, even those which are fairly mature, are left in a closely packed sack for two days, very few of them will germinate.

Good seed can be saved in Florida if it is carefully selected in the gathering and then dried properly. The freshly gathered sacks of seed should be emptied at noon and at night, or whenever brought to the barn, and the seed spread on the floor so it will not be more than a foot deep.

Prompt and thorough drying is essential to preserve the seed in good condition. After it is emptied from the sacks it should be stirred frequently, at least twice daily, until it is well air dried, after which it may be again put in sacks for storage. If the weather is very warm and dry, the seed may be dried in two or three days, but if cloudy and cool the drying may require a much longer time. The smaller the bulk of the seed and the more frequently it is stirred, the more quickly it will dry. If only ripe seed is gathered and it is thoroughly dried out at once, it may be kept in good condition for some years if stored in a thoroughly dry place. The seed is very light, weighing only 7 pounds per bushel when well packed.

A large quantity of this seed has been imported from Australia, as seed from that country has generally given a high germination, while the Florida seed has usually been found to have a low germination. This has given many growers a strong and probably justifiable prejudice in favor of the imported seed. Up to the present time the larger portion of the Florida-grown seed has been of poor quality, but there are a few growers who save seed of a higher viability than has been shown by imported seed which the Department of Agriculture has tested. Florida can produce as good seed as can be obtained anywhere, provided the growers will use proper care and intelligence in its gathering and curing. Ordinary Florida-grown seed is often sold for 25 to 50 cents a pound, while the imported seed usually costs about a dollar. Florida growers who save seed which is really better than the imported say that they can not afford to sell it for less than $1 per pound. In this case, as in most others, the low-priced seeds are really the most expensive. Poor seeds are expensive at any price. The chief essential in producing good Natal grass seed in Florida is intelligent gathering and handling.

TESTING THE SEED.

The quality of the seed is so variable that it should be tested before planting. This testing may be done by scattering a few seeds between pieces of damp blotting paper and retaining them in a warm room a few days, keeping the blotting paper constantly damp, but not wet. A still better method is to plant a few rows of seed in a box of soil, as tomato and cabbage plants are often grown. This testing should be begun at least a month before the seed is to be sown. If the seed proves to be good, from 3 to 10 pounds per acre should be used, while if it germinates poorly a correspondingly larger quantity should be sown.

VARIETIES.

There are several varieties of Natal grass, which are as distinct as are varieties of oats or corn. Some of these varieties show differences in color of seed, which varies from dark red to light pink, pinkish yellow, or nearly white; some have leaves of a bright-green color, while others have leaves which are almost blue and quite glaucous; some are killed by light frosts, while others live through moderately severe winters; some are nearly erect in growth, while in others the earlier stems soon become very decumbent and take root at the joints where the stems rest on the ground; in some, the leaves are very narrow, slender, and erect, while in others they are much broader and somewhat drooping.

Several varieties from Brazil and elsewhere are of such recent introduction that it is still impossible to say which may be of the greatest general value or which may have special value for special locations. All of these varieties, together with several others, are now being tested under ordinary field conditions in the expectation that distinct standard varieties will be developed in the near future.

It is quite possible that a mixture of varieties may prove more prolific than any one sort when grown alone. This, however, can be determined only by further field tests.

PASTURES.

Natal grass makes good grazing for cattle and horses during late summer and fall; but other pasturage is abundant at that time and can usually be had at less expense. Natal grass gives little grazing in winter and early spring. It does not grow well on ground which has never been plowed, and as the land on which it is grown should be plowed at least once every two years, it can not be recommended as a foundation for permanent pastures.

There are few permanent pastures in Florida except the native range in the pine woods, and as Natal grass makes a good growth only on soils which have recently been in cultivation it has little value as an addition to such permanent pastures as now exist.

It is not suited for use on the lawn, as it grows tall and does not make a turf.

SUMMARY.

(1) Natal grass is a subtropical grass which is valuable for cultivation in the United States only in the extreme South.

(2) Natal grass is the most valuable hay grass yet found for the sandy soils of Florida, and it will probably prove of value in southern Texas, and perhaps farther west in Arizona and California.

(3) Natal grass is best adapted for growth on well-drained sandy soils and apparently does not reseed itself freely on heavy soils.

(4) Natal grass is well suited for use as a summer crop, to follow such winter crops as oats or vegetables.

(5) When sandy land is once seeded Natal grass does not need reseeding if the land is plowed in the fall, a winter crop grown, and the land again plowed or disked in the spring.

(6) If the land on which Natal grass is grown is not used for a winter crop and not plowed, it will give not only a cutting earlier in the spring, but a greater number of cuttings during the season, though the total yield of hay will be about the same as if a winter crop had been grown.

(7) This grass is not desirable for lawns and is of only moderate value for pastures.

(8) The hay is of excellent quality, being easily cured, richer in protein than timothy, attractive in appearance, and very palatable.

(9) Natal grass seed of high quality can be grown in Florida, but care and intelligence must be used in its gathering and handling.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 727 JUNE 30, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

GROWING FRUIT FOR HOME USE IN THE GREAT PLAINS AREA.

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INTRODUCTION.

During recent years a transformation of large import has been taking place in the Great Plains area. From a vast territory devoted largely to the grazing of cattle and with a very small population it has become an area in which great quantities of grain and other crops are produced annually, with a corresponding increase

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NOTE.—This bulletin is intended especially for those in the Great Plains area who are interested in growing fruit for home use, but some parts of it, especially the discussion about pruning and shaping trees, are of general interest to people living in other sections of the country.

The information is based largely upon the results obtained in a dry-land fruit garden which was established in 1908 at the Dry-Land Agriculture Field Station of the Bureau of Plant Industry, Akron, Colo. Most of the illustrations are from photographs taken in this garden.

This bulletin supersedes Bureau of Plant Industry Circular No. 51, entitled "Fruit Growing for Home Use in the Central and Southern Great Plains."

in the number of homes. Though some sections are still very sparsely settled, the aspect of the entire area has been materially changed by the influx of people who have come from many different parts of the country.

The Great Plains area is not "a natural fruit country," as those regions in which native fruits abound or where the conditions are especially favorable for fruit production are often called. On the other hand, very few native fruits occur in this area, and comparatively little attention has been given to the planting of the cultivated fruits. However, many of the recent comers are from sections where they have been accustomed to grow what fruit was needed for home use. It naturally follows that in many instances upon establishing new homes in this area they have planted a few fruit trees. As a result there are numerous ranches widely distributed throughout the Great Plains where some attempts are being made to grow a home supply of fruit.

In a few instances orchards of some commercial importance have been developed. Most of these are the outgrowth of one or more of several conditions: (1) The location has proved to be exceptionally well suited to the growing of fruit; (2) the owner has had considerable experience in fruit growing before coming to this section; or (3) the owner, as he has gained experience here with a small orchard, has found himself better qualified for the details of fruit raising than the ranchers generally, and has gradually increased his fruit interests to good advantage.

The surplus fruit from the home orchards, as well as that produced in those of larger size, always finds a ready sale, buyers sometimes driving many miles to obtain it.

Within the boundaries of the Great Plains area there are a few restricted districts that are under irrigation. In some of these, orchard interests of considerable commercial importance have been developed. These interests are not discussed, however, in this bulletin.

The tree fruits that occur most commonly in the dry-land ranch orchards are apples, cherries, and native plums. In some of the milder parts of the area, especially in the southern section, pears and peaches are more or less common, while still less frequently apricots are found. Currants and gooseberries are probably the most important as well as the most common of the small fruits. June berries, buffalo berries, and strawberries are sometimes to be found.

The successes and failures in this area, as in other sections, are quite largely dependent upon the care and attention given by the owner. In certain regions, however, it is difficult to succeed, while in others a complete fruit failure is comparatively rare. The one controlling factor in the Great Plains area, outside of those sections where water for irrigation is available, is the lack of moisture, yet after the trees have become well established it is not often that this causes more than temporary loss, such as a crop of fruit for a single season.

In some sections winds and hailstorms occasionally cause damage, but these losses are not more frequent with fruits than with the field crops. However, the trees sometimes suffer permanent damage from hailstones, even being killed in some cases.

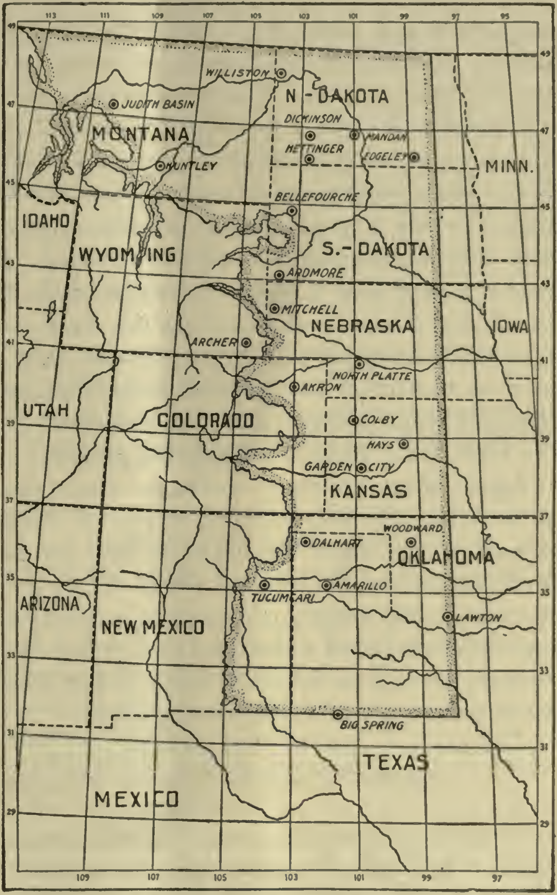

FIG. 1.—Sketch map of the Great Plains area, which includes parts of 10 States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. Each dot within a circle (⊙) indicates the location of a field station of the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry.

The majority of the settlers on the Great Plains must depend upon their own plantations for a supply of fruit for home use. Most of those who do not have home-grown fruit are obliged to do without it. The chief interest, therefore, in the cultivation of fruit in this area centers about the home and the production of enough to meet the needs or desires of each family. In other words, fruit growing here is a home-making rather than a money-making enterprise.

The geographical position and extent of the Great Plains area are shown in figure 1. Its western boundary, as indicated, is the 5,000-foot contour; its eastern boundary is arbitrarily placed at the ninety-eighth meridian.

SITES FOR FRUIT PLANTATIONS.

Probably the greatest obstacle, either directly or indirectly, to the successful growing of fruit in the Great Plains area is lack of moisture in the soil. It follows, therefore, that the site for an orchard or small fruit garden should be selected with a view to securing the maximum supply of soil moisture. In many instances, particularly on the smaller ranches, the conditions are so nearly uniform that there is no choice in this respect. The convenience of the site with regard to the buildings will usually be the ruling factor in such cases.

But on many ranches there are sites that are more favorable for fruits than others, on account of the soil-moisture factor; for instance, where a small stream or arroyo passes through the ranch it may furnish an additional supply of water. In some cases the topography is such that a reservoir can be made by building a small dam across the stream and diverting the water to the orchard. Not infrequently some of the larger streams that pass through this area have an underflow that extends some distance on either side. Where this condition prevails and the underflow is reached by their roots, the trees often make a remarkable growth.

Again, there are many instances where the lay of the land is such as to result in a large amount of run-off during heavy rains. If this run-off, which would otherwise be lost, can be collected in small contour ditches and distributed where fruits are planted, a considerable increase in the supply of moisture is secured. Sites for fruit plantings can be selected sometimes with reference to this possibility. Advantage should be taken of every factor which will increase or conserve the supply of moisture in the soil.

CLIMATIC FEATURES OF THE GREAT PLAINS.

"The climate of the Great Plains has been classified as semiarid. It may be better to say that it is variable. One season may have almost humid and another almost arid conditions. The mean annual precipitation is relatively low. Years of relatively high precipitation may be followed by years of relatively low precipitation. Other climatic factors usually correspond with the rainfall. In a year of relatively high rainfall there will be a lower rate of evaporation and higher humidity than in a year of low rainfall.

"Another climatic factor of much importance in crop production on the Plains is the distribution of the rainfall. This is probably more important in crop production than the amount of annual rainfall. A relatively low rainfall, properly distributed, may produce a crop where a much higher rainfall, unfavorably distributed, may accompany a crop failure.

TABLE I.—*Annual and seasonal precipitation and seasonal evaporation at fourteen stations in the Great Plains area.*[1]

Station.	Altitude (feet).[2]	Precipitation (inches).[3]						Seasonal evaporation (inches).[3]		
		Annual.			Seasonal.					
		Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.
Judith Basin	4,228	14.96	23.78	18.06	7.04	17.21	9.34	22.012	29.353	24.491
Huntley	3,000	11.92	11.92	11.92	5.92	6.02	5.97	23.754	24.214	23.984
Williston	1,875	10.28	18.99	14.84	4.75	14.49	9.66	20.422	26.877	24.216
Dickinson	2,543	11.93	21.22	16.69	6.85	16.28	9.79	20.673	25.745	23.919
Edgeley	1,468	11.94	21.95	16.71	7.85	14.98	10.11	18.663	24.893	21.866
Hettinger	2,253	12.72	15.68	14.20	8.92	12.47	10.36	21.539	28.239	24.639
Belle Fourche	2,950	6.64	17.73	13.11	4.08	9.78	6.90	26.472	33.750	28.794
Scottsbluff	3,950	13.77	18.51	16.14	2.53	8.52	4.69	23.804	29.381	26.081
North Platte	3,000	11.18	23.01	18.05	6.85	12.36	9.45	28.445	38.168	32.359
Akron	4,600	14.51	22.46	18.28	6.42	13.86	9.02	26.064	35.654	31.420
Hays	2,050	15.59	27.80	21.30	8.18	17.97	11.17	30.625	44.373	35.790
Garden City	2,900	11.82	23.58	18.54	2.79	14.43	8.65	34.325	43.510	38.185
Dalhart	4,000	13.69	16.35	15.11	5.09	9.85	8.01	35.459	41.748	38.988
Amarillo	3,676	10.69	27.80	18.28	6.17	11.38	9.13	33.804	42.076	36.724

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[1] The period of time covered by the investigations made at the several stations ranged from two to eight years, depending upon the time when the different stations were established, the same period being covered by the data regarding precipitation and evaporation shown here.

[2] The altitude given is based in most cases on that of the nearest town.

[3] The records of annual precipitation for 1914 are not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, being figured from May 1 to Sept. 1. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground.

"Table I gives the maximum, minimum, and average annual precipitation and the seasonal maximum, minimum, and average precipitation and evaporation of the Great Plains area. By seasonal is meant the period between the average time of seeding and the average time of harvest. * * *

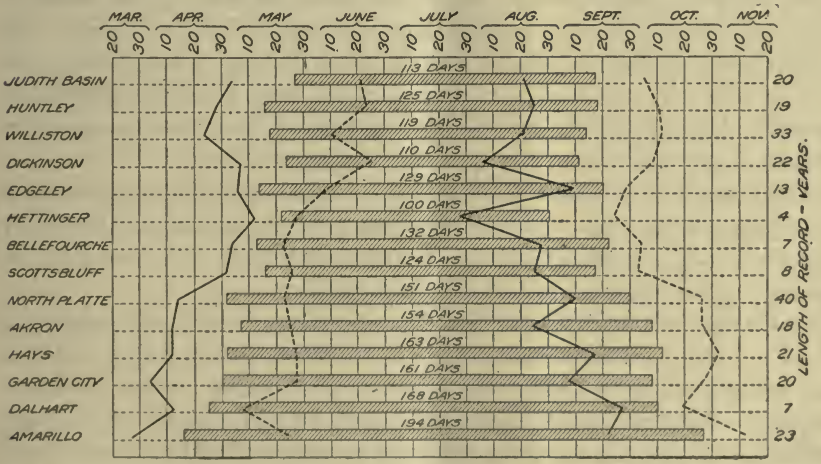

FIG. 2.—Diagram showing the average frost-free periods and the earliest and the latest dates at which the last killing frost in the spring and the first killing frost in the fall has occurred at fourteen stations in the Great Plains area.

"Figure 2 shows the earliest and latest dates of the last killing frost in the spring, the earliest and latest dates of the first killing frost in

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the fall, and the average length of the frost-free period at each station. Each hatched horizontal bar represents the period between the average dates of the last killing frost in the spring and the first killing frost in the fall. The number of days in the average frost-free period for the station is shown in the figures above the bar. The solid-line curve at the left shows the earliest date at which the frost-free period has begun. The broken-line curve at the left represents the latest date at which the last killing frost of the spring has occurred. The solid-line curve at the right represents the earliest date and the broken-line curve at the right the latest date at which the first killing frost of the fall has occurred.

"This diagram [fig. 2] shows clearly the increase in the length of the frost-free period from the north to the south. The shortest average period is 100 days, at Hettinger, and the longest 194 days, at Amarillo."[1]

In the Great Plains area the regional restrictions to fruit growing, so far as the natural conditions are concerned, are primarily factors of temperature and moisture.

In some sections of this area, especially the northern part, fruits for planting must be selected with a view to their hardiness and their ability to endure extremely low temperatures in winter. But throughout the Great Plains area as a whole unseasonable frosts during the blossoming period or at other critical stages of growth more often cause damage than extreme cold during the dormant period. However, the combination of relatively low winter temperatures, limited moisture supply, and drying winds that sometimes prevail is extremely trying on most fruit trees and may cause serious damage where any one or even two of these factors operating at the same time would not adversely affect the trees.

The general climatic features of this area are well indicated in the paragraphs above quoted. In that connection the statements are applied to the production of general agricultural crops, but they are none the less applicable to fruit growing.

Another climatic factor that occasionally does great damage is hail. Trees of considerable size are sometimes completely killed or so badly bruised or otherwise injured as to render them worthless. Hailstorms occur much more frequently in some parts of this area than in others. In sections where they are known to be severe, the planting of fruits is likely to prove disappointing.

Some sections of the Great Plains are further characterized by winds which blow almost continuously. While the wind may not be a prohibitive factor in the growing of fruit in any section it is a serious one where it blows much of the time. It not only results in the premature dropping of the fruit, but it becomes practically impossible to prevent the tops of the trees from growing very much to one side.

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[1] See Chilcott, E. C., Cole, J. S., and Burr, W. W., "Crop production in the Great Plains area: Relation of cultural methods to yields," U. S. Dept. Agr. Bul. 268, p. 4, fig. 2. 1915.

PREPARATION OF THE LAND FOR PLANTING.

For fruits, land that has been in cultivation for one season or for a sufficient length of time for the sod to have become thoroughly rotted is very much to be preferred to newly broken land.

The planting of fruits in this area should be done as a rule in the spring, and in any special preparation that may be made the aim should be to handle the soil so that it will contain as much moisture as possible at the time the planting is done.

In seasons of fairly abundant precipitation, especially if there is considerable rainfall or fairly heavy snows during the winter, there may be enough moisture stored in the soil in the spring to insure the starting of the trees, even if a crop has been produced the previous season. But because of the wide seasonal variation in the amount of precipitation, frequently falling far below normal, and the importance of an abundant supply of soil moisture in the spring at planting time, it is generally advisable to summer-fallow during the season that precedes the planting.

In addition to summer-fallowing, an adequate supply of soil moisture is still further insured if deep furrows are opened in the fall along the lines of the tree rows. These will serve to collect both the drifting snow and some of the run-off during heavy rains which might otherwise be lost.

One very successful fruit grower on a dry-land ranch even supplements the furrows by digging in the autumn rather large holes where the trees are to stand. The run-off, as well as the snow caught in the furrows, will tend to settle in the holes and thus still further augment the amount of moisture in the soil in the immediate radius of the trees. In some cases, cross furrows or furrows made at an angle to the direction taken by the run-off and leading to the holes might also be useful.

Under ordinary climatic conditions this method of preparing the land should result in its being well supplied with moisture, and the trees should start into growth readily and make a good development of roots so far as the soil moisture is concerned.

NURSERY STOCK.

In the central portion of the Great Plains area, as represented by the Akron Field Station, Akron, Colo. (fig. 1), the most favorable period for planting is usually the last of April and early in May.

It varies in other parts of the area from earlier in the southern section to somewhat later farther north. Normally, nursery stock is delivered in the spring rather than in the autumn. It is absolutely essential for success that it reach its destination in a perfectly dormant condition. Hence, it follows that while it may be satisfactory for those ordering stock for planting in the southern part of the area to secure it from northern sources, it is not well to obtain it from the south for planting in the northern sections, on account of the fact that the buds may start on stock from the south before the most favorable period for planting in the north has arrived.

On account of the arid or semiarid conditions of this region the period following the planting of the trees is very trying unless there is a sufficient supply of moisture stored in the soil and available for their use. The moisture in the trees is being dried out constantly, and more rapidly than would be the case in a humid region. The roots of newly planted trees do not at first readily take up moisture from the soil, and if it is excessively dry the trees may die before they can start into growth. Because of these moisture factors it is of the greatest importance to secure only trees and other nursery stock which are most likely to start into growth readily and quickly when planted.

In many fruit-growing regions apple, pear, plum, and cherry trees are commonly planted when 2 years old; that is, after they have made two seasons' growth in the nursery from the bud or graft. However, in some commercial apple and cherry growing sections there is a strong sentiment in favor of 1-year-old trees for planting in preference to older ones. The younger trees have an advantage in that it is possible to form the tops at any desired height. The heads are already formed on 2-year-old trees when received. Not infrequently the trees have been headed too high to be desirable, and it is not always possible or practicable to plant such trees deep enough to overcome this objection. And, again, good, strong 1-year-old trees as a rule withstand transplanting fully as well as older trees; they are lighter to handle in shipping and in other ways are more desirable. This is true of other trees as well as of apples and cherries.

Inexperienced buyers of fruit trees not infrequently measure the value and grade of the trees delivered by their size; the larger the tree the better it is supposed to be. But experience has proved that thrifty, medium-sized trees are better for planting in the Great Plains area than larger ones, with a preference for good, strong 1-year-old trees. The larger 2-year-old trees as a rule do not withstand transplanting as well, nor are they as likely to live and make a good growth as the medium-sized ones of the same age.

On the other hand, a very radical distinction must be made between medium-sized or relatively small healthy trees and those which are small because they have been stunted by some adverse condition. Weak, stunted trees should be refused absolutely. They are likely to be expensive even as a gift.

Good root systems are also of special importance in satisfactorily starting trees planted under the conditions which normally prevail in this area. In sections where all the factors influencing growth are favorable, the difficulties incident to poor roots, if not too serious, may be overcome perhaps without permanently harmful results; but in the region under consideration well-developed and abundant root systems are especially important. If the roots of trees consist of only a very few large parts, new growth does not start as readily and as quickly as it does if the plants are well provided with a large number of small roots.

But here again caution is necessary. A large mass of very fine threadlike roots is due cause for suspicion. Such roots may indicate a disease known as hairy-root, a form of crown-gall. While there is a wide difference of opinion and experience concerning the seriousness of this trouble, it is by far the safer plan to discard trees so affected; the roots in any event are abnormal and if planted there is always the possibility that the trouble will develop to such an extent as to affect seriously the vigor and durability of the tree. All trees and vines showing crown-gall or abnormal growths of any kind should be rejected.

The height of the tree is as important as its root system. Trees that have been headed from 1½ to 2½ feet high as a rule start into growth more readily and develop better than trees headed 3 to 3½ feet high. In a large majority of cases the high-headed trees, even when they live, make only a very small growth the first season and rarely develop well-formed, satisfactory tops as they increase in age.

HANDLING THE STOCK WHEN RECEIVED FROM THE NURSERY.

It has already been stated that planting in the spring rather than in the autumn is to be advised in this area. To insure the timely arrival of the stock from the nursery it is wise to order it shipped with a view to its arriving at its destination a little in advance of the actual date of planting. Otherwise, an unexpected delay in shipping or during transit may result in inconvenience or in the undue starting into growth of the stock before it is received.

To hold trees and other plants in good condition until planted, they should be unpacked immediately upon arrival and heeled in without delay in a well-drained spot. The heeling in is accomplished by digging a trench 12 or 15 inches deep, sloping on one side. The roots are placed in the trench, the trunks of the trees lying at right angles to it on the sloping side. The position is illustrated in figure 3.

In case the trees are tied in bundles when received they should be separated; otherwise, the roots can not be properly protected. Moist, finely pulverized soil should then be worked thoroughly in among the roots, completely filling all the spaces, and the roots finally covered several inches deep.

If it is necessary for any reason to have the trees heeled in for a long time before they are planted, it may be advisable to cover the tops, entirely or nearly so, with soil, to prevent the sap from being dried out to an undue extent. With the first advent of warm weather, however, the branches should be uncovered.

The soil that is placed over the roots and such other parts of the trees as may be covered should be packed very firmly. This is not only for the purpose of excluding as much air as possible, but to lessen the danger of mice finding a harbor among the trees, where they might cause injury by gnawing the bark.

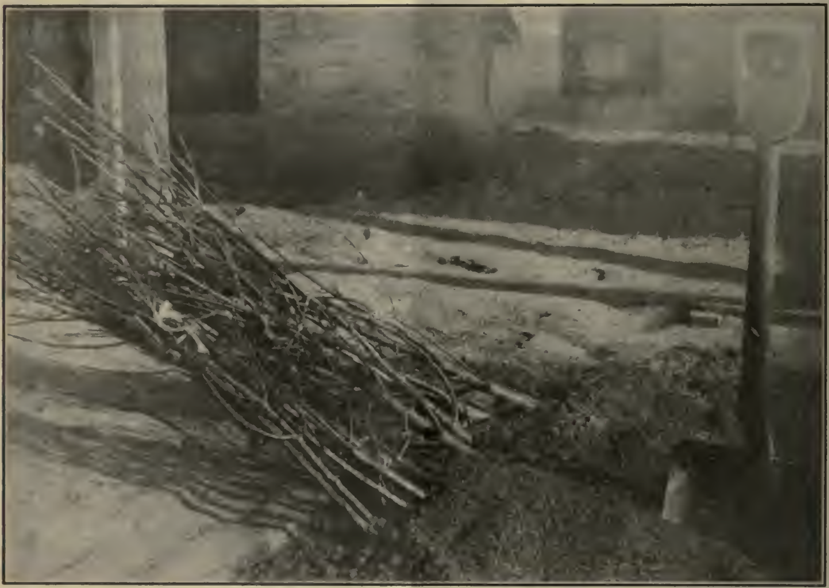

FIG. 3.—Peach trees heeled in. The position in which the trees are placed is to be noted.

Trees that are heeled in should be examined frequently, with especial reference to moisture conditions. While the soil about the roots should not be kept in a water-soaked condition, it should not be permitted, on the other hand, to become thoroughly dry. The sap in the trees would be likely to dry out and the bark shrivel if this should occur. Difficulties of this sort can be avoided easily by the judicious application of water.

Berry bushes and other small fruits are handled in essentially the same manner as trees, but the trenches in which the roots are placed are shallower than for tree fruits, to correspond with the size of the plants.

PLANTING THE TREES AND OTHER NURSERY STOCK.

The most satisfactory time for planting fruit trees and bushes in eastern Colorado in the average season is the last of April or the first of May. The soil is usually in good workable condition at this time, and as a rule it is a period during which there is considerable precipitation. These conditions are favorable for growth, and if a tree or other plant reestablishes itself readily in its new place and growth begins promptly one of its most critical periods is past.

The best time for planting fruits in the other parts of the Great Plains area may vary somewhat from the dates for Colorado given above. Generally, it may be done earlier in the southern sections and later in the north. It should be done after the danger of hard freezing temperatures is past and when the soil is in good condition for working.

The method of planting fruit trees in this area does not differ in any essential from that commonly followed in other parts of the country. In handling the trees every possible precaution needs to be taken to prevent the roots from becoming dry when the trees are removed from place to place. The roots should not be exposed to the air more than is absolutely necessary. Covering with wet burlap is, perhaps, the most convenient means of giving protection, but wet chopped straw, damp moss, or other materials that can be moistened and covered over the roots may be made to serve the purpose; or the roots may be protected by puddling them. This consists merely in dipping the roots in a puddle of clay. The clay should be of such consistency that a thin layer of mud will adhere to the roots when they are dipped into it and at the same time permit them to be moved about in it with perfect ease and freedom. Such a coating of mud will afford considerable protection against undue drying out from exposure to sun and wind. By observing this precaution at all times, including the period of exposure incident to planting the trees, there should be no loss due to dried-out roots.

The holes are made broad enough to receive the roots without bending them from their natural position and deep enough so that when filled even with the surrounding surface the trees will stand 2 or 3 inches deeper than they did in the nursery. Sometimes the holes are made in the autumn, as previously described.

Before planting, the ends of all broken roots and roots otherwise injured should be removed with a smooth cut. As the trees are placed in position in the holes the soil is carefully worked around the roots and firmly packed by tramping. If the soil is moderately moist it will not be necessary as a rule to water the trees when planted; but if the soil is dry it may be well to pour a pail or two of water into the hole after it has been partially filled with soil, and then complete the filling after the water has soaked in. The subsequent use of water should be governed by conditions. If it continues dry after the trees are planted an occasional application of water sufficient to keep the soil in the vicinity of the roots well moistened may enable the trees to grow readily when otherwise they might fail entirely from lack of moisture.

When the trees are planted they should be headed back to the desired height. It is believed from experience and observations under Great Plains conditions that the main stem or trunk of the tree should not exceed 2 or 2½ feet in height, measuring from the surface of the ground after the tree is planted. In many cases the heads may well be formed even lower than this. Trees with low heads are not as likely to be injured by sun scald as those with high heads, nor are they as much affected by the wind. If the trees have been headed in the nursery, as is the case with stock 2 years old, it is often impossible to handle them so as to place the heads at the desired height. With 1-year-old trees this difficulty does not exist.

There is a wide difference of opinion and practice among fruit growers as to the details to be observed in shaping the permanent head of the tree, but the conditions attending tree growth in this area are such that it is believed an open head which develops from a few main branches is preferable to one so managed that it becomes dense and bushy.

To develop an open head, only four to six branches should be left when the tree is pruned at the time it is planted, or when it is formed later if 1-year-old trees have been used. These branches should be selected with a view to their position on the trunk. They should be arranged symmetrically and spirally about the trunk and should start from different levels, thus leaving some space vertically between the different limbs. If two limbs branch from the trunk at the same level there is much more danger that they will split down in later years under the weight of a large crop of fruit or during a heavy wind than where the formation is as suggested above.

The branches selected for the permanent top of a 2-year-old tree should be cut back considerably at the time the tree is planted. If the tree has made a fairly vigorous growth in the nursery the preceding season, one-half or two-thirds of the length, as a rule, may be cut away. This will tend to make the branches strong and stocky rather than slender and "leggy," as when no cutting back is done.

This plan of forming the head also reduces the number of branches which the roots are required to supply with moisture during the first season's growth. It should be kept in mind that a considerable portion of the root system is lost in digging the tree from the nursery and that the branches need to be reduced proportionally.

The plan described is illustrated in figure 4 and still further shown in figures 5 to 10. Figure 4 shows a McIntosh apple tree in July of its second season's growth in the Akron fruit garden. It was headed low, the number of permanent branches was reduced to four or five, and from the very beginning the top has been kept open. The same plan of development may be seen in the other illustrations mentioned.

The method followed in planting small fruits is essentially the same as that described for tree fruits. They are planted, as a rule, a little deeper than they They are cut back, were originally. if necessary, to make the tops correspond to the root system, and in other respects the directions given above are readily adapted to handling small-fruit plants.

Because the roots of small fruits are nearer the surface than those of tree fruits it may be necessary to give more attention to watering newly set plants until after they start into growth than is suggested for trees. This applies with special emphasis to strawberries.

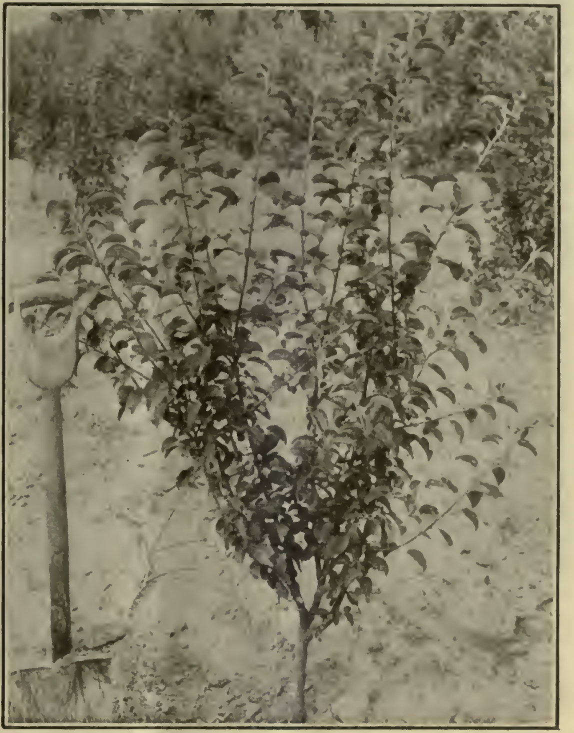

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FIG. 4.—A McIntosh apple tree in July of its second season's growth, which has been pruned with a view to developing an open head. Akron, Colo., July 19, 1913.

PROPER DISTANCES FOR PLANTING.

The distance between fruit trees is a matter of greater importance than is commonly realized. The space unoccupied at the time the small trees are planted seems out of proportion to their size, but the requirements when the trees are mature must be anticipated. It should be remarked that the roots extend very much farther than the spread of the branches, contrary to a commonly expressed notion. At Cheyenne Wells, Colo., the roots of a 14-year-old apple tree were traced 26 feet in one direction from the tree and some 9 or 10 feet in the opposite direction, making a spread of at least 35 feet; in fact, the actual spread was several feet more than this, as it became impracticable to trace the roots in the very dry, hard soil to their ends.[1]

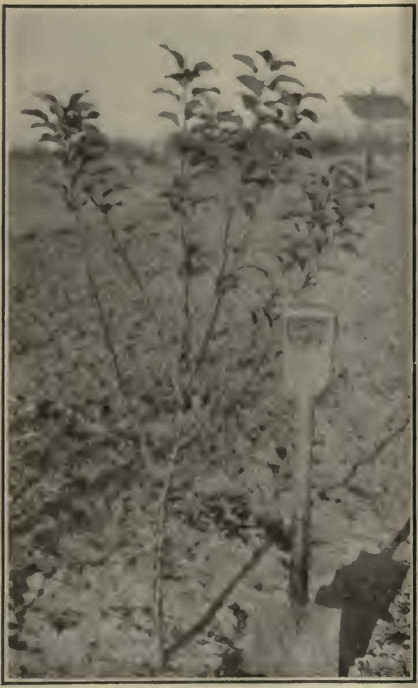

FIG. 5.—A Delicious apple tree after two seasons' growth as it appeared before its annual pruning. The foundation for the top consists of four or five main limbs.

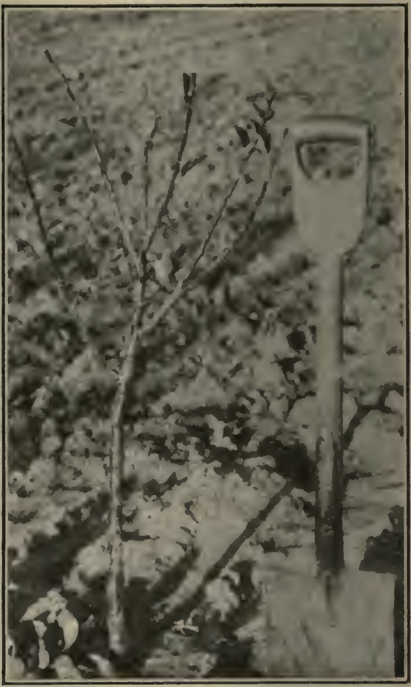

FIG. 6.—The Delicious apple tree shown in figure 5 after being pruned. Both figures were reproduced from photographs taken at Akron, Colo., November 12, 1914.

The great number of roots that develop on apple trees under semiarid conditions is suggested by figure 11, and the expanse of the roots is shown in figure 12. It was 26 feet from the stump to the end of the root held by the man shown on the left in the illustration (fig. 12).

It therefore appears that trees may suffer earlier in their life from the crowding of the roots than from the crowding of their tops. The bearing which these facts have on the welfare of the trees is largely in relation to the moisture supply. If the trees are too close together their combined moisture requirements may exceed that furnished by normal precipitation.

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[1] This study of the root systems was made in August, 1910, at the Dry-Land Substation of the Colorado Agricultural Experiment Station by Mr. J. E. Payne, then connected with that station, and one of the writers. For further details, see Payne, J. E., "Notes on a dry-land orchard," Colo. Agr. Exp. Sta. Bul. 173, 7 p., illus. 1910.

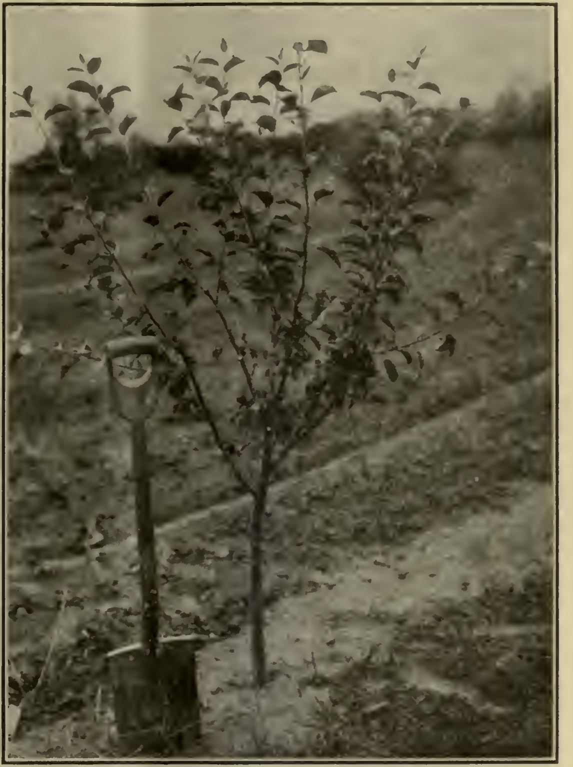

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FIG. 7.—The same Delicious apple tree shown in figures 5 and 6 as it appeared in July of the following season. The buds near the ends of the stubs in figure 6 have developed into branches, thus making a good framework for the development in the future of a strong well-branched tree. Akron, Colo., July 21, 1915.

Too close planting is a common fault in many of the commercial fruit-growing districts in irrigated as well as in humid sections. Its results in semiarid sections where irrigation is not practiced are likely to be particularly serious.

While fruit trees may not grow as large under the semiarid conditions of the Great Plains as in humid sections, it is not believed that this fact is sufficient to warrant close planting. On the other hand, the size attained here by trees is likely to be governed very largely by the amount of moisture available.

In the light of the foregoing statements the following distances each way for the planting of different fruits are suggested:

Apples, 30 to 35 feet.
Pears, 25 to 30 feet.
Peaches, 20 to 25 feet.
Plums, 20 to 25 feet.
Cherries, 20 to 25 feet.
Sand cherry-plum hybrids, 10 to 15 feet.
Currants, 5 to 6 feet.
Gooseberries, 5 to 6 feet.
Raspberries, 6 to 7 feet.
Blackberries, 6 to 7 feet.
Strawberries, usually in rows 3 or 3½ feet apart, with the plants 1½ to 2 feet apart in the row.

Many of these distances may seem excessive at first, but they allow none too much space when the demands of mature trees and other plants for moisture and plant food are taken into account.

TILLAGE.

The tillage (or cultivation, as it is more commonly termed) of a fruit garden or orchard in this region should be very thorough. Its primary object is to conserve the soil moisture to the greatest possible extent. If this is done, the other objects of tillage will generally follow as a matter of course. Usually, it should be continued fairly late in the season. In 1910 the seasonal cultivation in the dry-land ranch garden at Akron was discontinued early in August. This was done in order to avoid further stimulation of growth and to insure a thorough ripening of the wood before the advent of cold weather. However, no beneficial results followed that could be attributed to the cessation of cultivation as early as this; and, besides, it might prove a rather hazardous plan in some seasons. The growth of weeds following the cessation of cultivation so early in the season was sufficient to make a serious drain on the supply of soil moisture. The danger lies in the fact that the moisture in the soil might be reduced

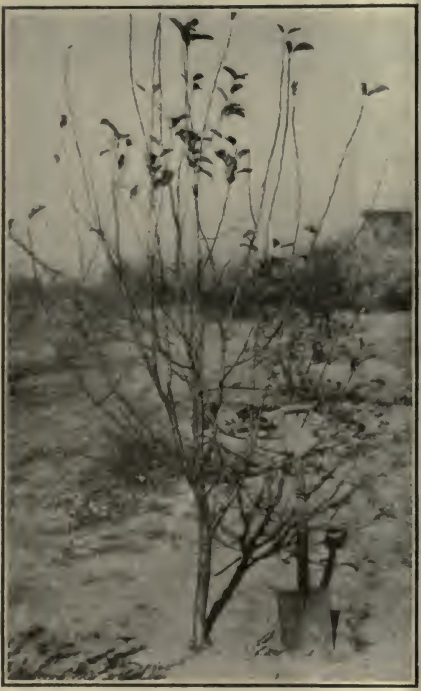

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FIG. 8.—An Utter apple tree after its third season's growth as it appeared before its annual pruning. In previous years the pruning has been directed toward keeping the top open.

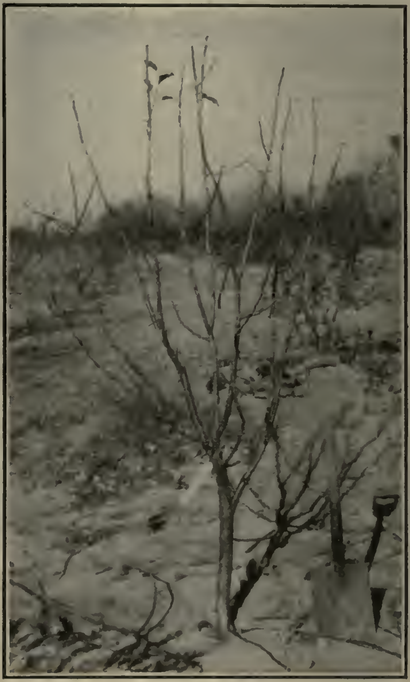

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FIG. 9.—The Utter apple tree shown in figure 8 after being pruned. Both illustrations (figs. 8 and 9) were reproduced from photographs taken at Akron, Colo., November 11, 1914.

to such an extent that the trees would suffer during the winter or the following season in case there was little precipitation.

Tillage in the garden at the Akron Field Station has been frequent enough to destroy weeds before they have made any considerable growth, to prevent the soil from blowing, and to insure against any run-off during heavy showers. To these ends the surface has been kept in a rough, granular condition. In accomplishing these objects, the soil moisture has been well conserved against evaporation from the surface. Tillage has usually been continued until the latter part of August, or late enough to prevent any considerable growth of weeds and to avoid all danger of their going to seed.

This practice with regard to tillage has given good results in the Akron garden. Moreover, in its general principles it has been followed by ranchers in other sections of this area in the successful growing of fruit. Slight modifications of this plan of tillage may be necessary under some soil and climatic conditions, but it is believed that it embodies the essential features, so far as this operation is concerned, in maintaining orchards and fruit gardens in this area, not only while they are young, but after they reach maturity.

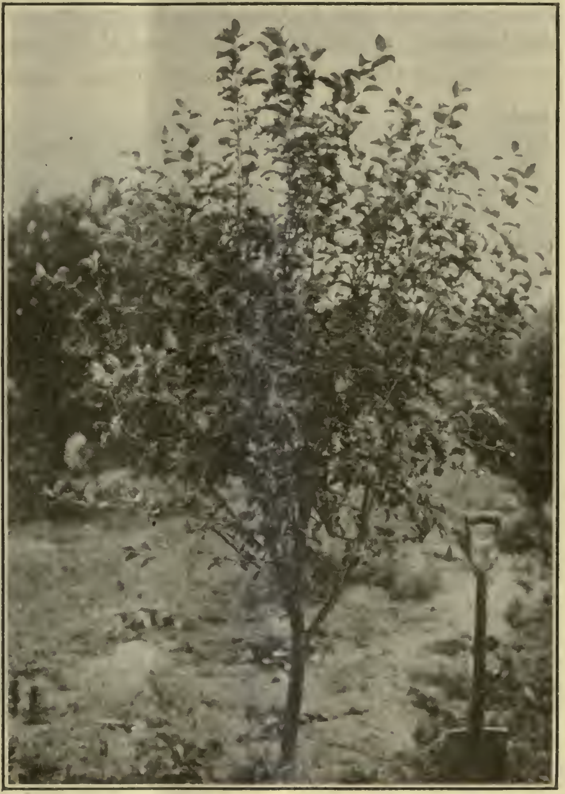
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FIG. 10.—The same Utter apple tree shown in figures 8 and 9 as it appeared in July of the following year. Akron, Colo., July 21, 1915.

Clean tillage throughout the season during the early life of an orchard amounts practically to summer fallowing. During the first three or four years and before the roots have extended very far, the demands made by the trees upon the soil moisture are comparatively small. With normal precipitation, the tendency obviously would be for the percentage of soil moisture in the spaces between the trees to increase rather than to decrease under this method of management. In this way, the greater demands of the trees for moisture as they reach larger size are anticipated in a measure, at least for a time.

Cover crops and green-manure crops serve a most important purpose in maintaining the fertility of orchard soils in humid and irrigated sections, but in this area where the soil moisture is so largely the limiting factor their use rarely, if ever, can be advised. The growing of these crops usually would draw so heavily upon the moisture in the soil that they would be a menace rather than a benefit to the fruit. The humus furnished by such crops in sections where they can be grown must be supplied here by applying manure or vegetable matter in some other form.

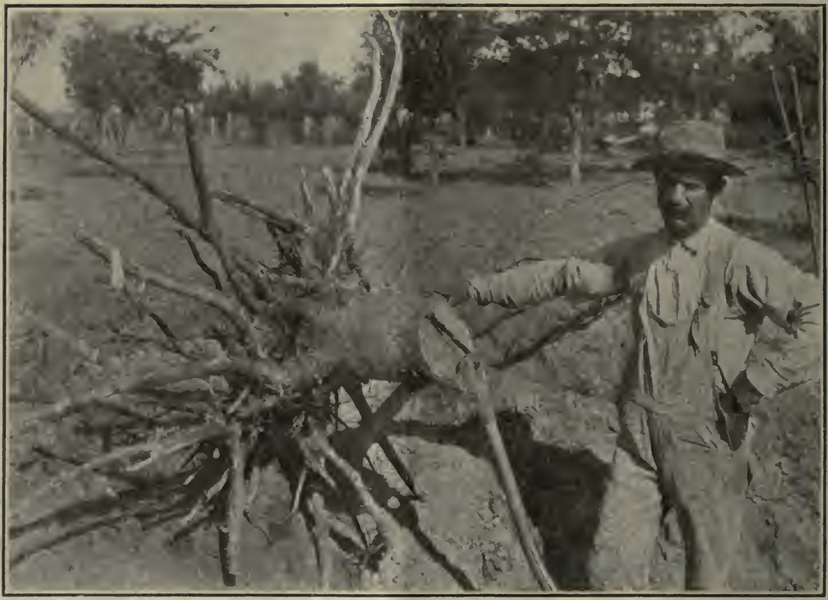

FIG. 11.—Part of the root system of a 14-year-old Ben Davis apple tree. Colorado Experiment Station, Plains Substation, Cheyenne Wells, Colo., August 11, 1910.

For a similar reason the interplanting of crops between the rows of trees in young orchards, as is commonly done in commercial fruit-growing sections, can not be recommended in this area. In the case of apple trees planted 30 or 35 feet apart, a row or two of corn or some vegetable possibly could be planted for the first two or three years midway between the rows of trees without irreparable harm to the latter, but the wisdom of even this limited competition with the trees would be doubtful in most cases.

The tools used in cultivating fruits may be a disk harrow, corn cultivator, or shovel cultivator, as conditions or convenience may dictate. While there are specially constructed orchard-tillage implements, the same tools used in the cultivation of general crops may be used advantageously in most cases.

PRUNING.

There is probably no phase of fruit growing on the Great Plains which requires greater care and attention in order to secure the best results than the operation of pruning. While this is especially true of tree fruits it is also of importance with small fruits.

One of the commonest faults to be found with fruit trees on many ranches in the Great Plains area is the density of the tops. This fault, however, is not more characteristic of fruit growing in this area than it is in many other parts of the country. It is a natural consequence in the first place of planting trees without properly forming the heads at the time they are set out and of improper pruning or no pruning at all in after years. In fact, as will be illustrated later, it is often practically impossible to correct the faults incident to improper pruning at the time of planting by pruning when the trees are several years old.

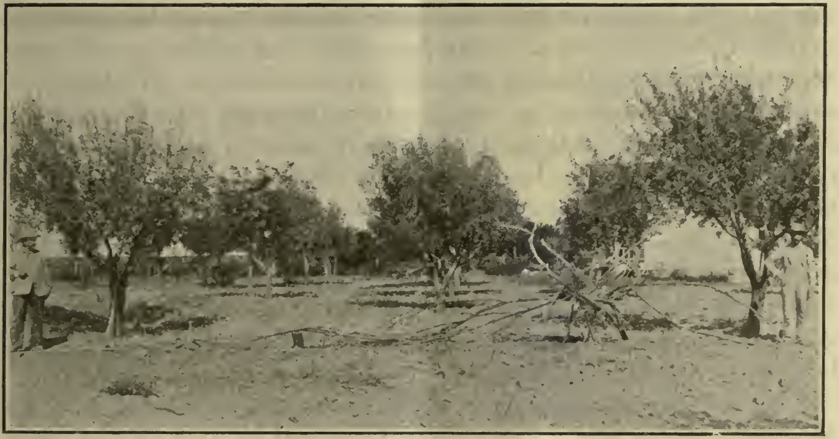

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FIG. 12.—The same stump of a Ben Davis apple tree shown in figure 11. The roots were traced a distance of 26 feet on the left and 9 or 10 feet on the right. The small extremities of the roots, amounting probably to several feet in length, still remained in the soil.

If only a single idea were to be kept in mind in pruning a fruit tree throughout its life, that idea might well be to keep the top sufficiently open to admit air and sunshine freely. If this is accomplished, most of the other objects for which fruit trees should be pruned will also be realized.

The fear that the branches will be injured by exposure to the sun is frequently offered as a reason for allowing the tops to become very dense. It is true that where a large limb which has been shaded continually is suddenly exposed to the direct rays of the sun serious injury may result, but when a tree is grown from the beginning with an open head and is properly pruned there is little danger from this cause.

In further understanding the principles of pruning, the reader will be assisted by reference to the accompanying illustrations, most of which are made from photographs taken in the Akron fruit garden.

Figure 4, previously referred to in connection with the planting of trees, shows also the pruning which was done following the first season's growth. The limbs were cut back to the points just below the level of the upper part of the spade handle, where the secondary branching may be seen. Branches which may have crossed each other and other superfluous growth were also cut out. While the top is open, it will be observed that the main limbs are well protected by leaves that developed from short spurs or buds. In a very dense top there would be but little development of leaf-bearing spurs along these limbs. The photograph reproduced here was taken in July, 1913. A good, strong current season's growth is evident. This growth would normally be headed back during the dormant season following the growth made in 1914, and such thinning out as might seem necessary to maintain the top in a well-opened condition would be done at the same time.

Figure 5 shows a Delicious apple tree that was planted in the spring of 1913. The top was lightly pruned in July of that year, the superfluous branches being removed. This figure shows the tree as it looked in November, 1914. The current season's growth of some of the branches was 2 to 3 feet, with practically no side branches. Figure 6 shows the same tree after it had been pruned. The results of this heavy heading back in November, 1914, become apparent by reference to figure 7, which shows the same tree in July, 1915; that is, during the middle of the following season's growth.

The strongest growth has taken place from buds near the ends of the stubs of branches shown in figure 6. This is resulting in a well-proportioned stocky tree, yet one which can be kept well opened to the air and sunshine with a minimum amount of pruning. Had this tree been left, as shown in figure 5, without heading back, the branching during 1915 would have occurred probably from buds near the ends of the branches, thus making a top composed of long, slender, "leggy" limbs instead of having the compact framework that is seen developing in figure 7. Perhaps this tree is not quite as tall now as it was in figure 5 before it was pruned in November, 1914, but it is more stocky and in better shape for its future development than it would be if it had not been headed back.

Figures 8 and 9 illustrate still further the idea expressed in figures 4 to 7 with reference to developing trees with stocky, open tops. These show an Utter apple tree that was planted in the spring of 1912. The photographs from which these illustrations were made were taken in November, 1914, before and after pruning. The tree then had completed three seasons' growth. From the beginning, it has been handled with a view to keeping the top open. As may be seen from figure 8, in comparison with figure 9, it was necessary to remove but little wood at this pruning, even though the current season's growth had been quite strong, many of the limbs having increased 2 feet or more in length. The tree was started the first year with a framework of four or five branches. With these to serve as a foundation and with a small amount of corrective pruning each year the tree remains within easy control.

In contrast with the average apple tree to be found in this area, the one shown in figure 9, as it here appears, may seem to many to be entirely too open. During the next season, however, the development of leaves and many small side branches, which may be expected eventually to form fruit spurs, causes the tree to present a very different appearance, as shown in figure 10. As seen here it is in its fourth season's growth. It will not be headed back very much in the pruning which it receives in the future. Heavy heading back tends to stimulate additional wood growth. This tree has now been well shaped. The limbs that form the framework of the top, as well as the trunk, are stocky and strong. It is in good condition to begin to bear fruit. There is, therefore, no further need of pruning to encourage additional wood growth, but more or less thinning out of the top probably will be necessary each year. Slight heading in at times may be advantageous, but the foundation work, so far as pruning is concerned, has now been completed.

The keeping of the top well opened during the first few years is favorable for the development of spurs and short branches along the limbs, thus tending to the production of a large bearing surface. It is on such growth that many fruit buds subsequently develop. This so distributes the fruit on the main limbs that there is the least possible danger of their breaking from its weight.

It should be stated, however, that there is much yet to be learned about the effect of heading back the annual growth year after year. If trees with strong stocky limbs are to be developed, rather heavy heading in for several years after planting seems as a rule to be necessary. On the other hand, there is considerable evidence that if this practice is carried too far it very materially retards the time of bearing. Moreover, in this respect, it seems probable that trees of different varieties should be handled differently. Some varieties naturally make a strong stocky growth and do not branch excessively, while others develop long, slender branches. Obviously these two types of trees should be treated differently with respect to pruning.

It is, of course, desirable that a tree should come into fruiting as early as possible after it is planted, but the gain of a year or two in earliness of bearing is of small importance compared with the development of a type of tree which in later years will best meet the ends for which it is grown. It is the nice balance between earliness of bearing and other characteristics and the development of a tree which in the long run shall be best suited to fulfill the ends in view that constitutes the real problem in pruning during the early life of an orchard.

In rather strong contrast to the trees shown in figures 4 to 10 are those in figures 13 to 17. The latter illustrate apple trees planted in the spring of 1908. The photographs used in making these illustrations were taken in November, 1914, after the trees had completed their seventh season's growth. Because these trees are considerably older than those shown in figures 4 to 10, the illustrations in the two groups are obviously not entirely comparable. Yet they show certain contrasts that are of fundamental importance in pruning fruit trees at the time of planting and during the first three or four years thereafter.

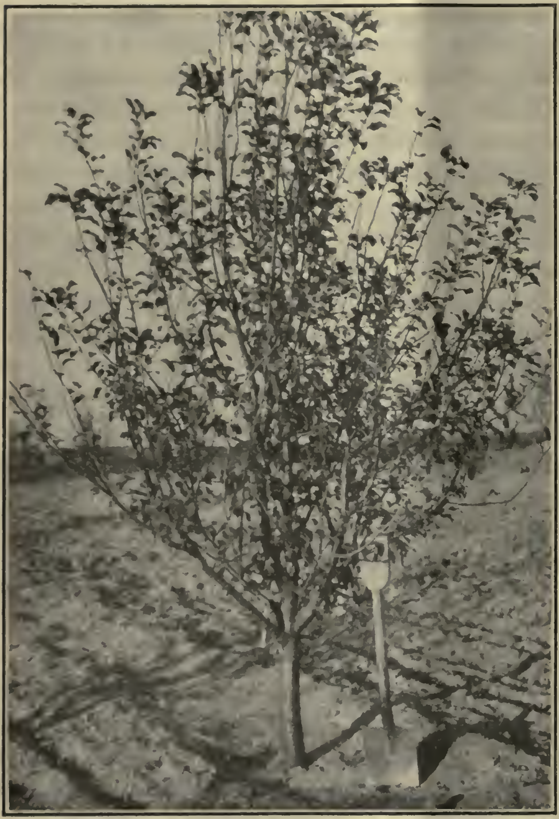
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FIG. 13.—A Wealthy apple tree planted in the spring of 1908, which received no further pruning until after its third season's growth. Because of these years of no pruning it has not been possible in more recent years to bring the top to a desirable form. Akron, Colo., November 11, 1914.

In contrast to figures 4 to 10, figures 13 to 17 show apple trees that were not trimmed with any particular ideal in view when they were planted, and they received no further pruning until after they had completed their third season's growth in 1910. Since then they have been pruned each year. To the casual observer the objectionable features of these trees may not be conspicuous, but they become very real to the one who wishes to prune them in a rational manner.

Figures 13 and 14 show a Wealthy apple tree and figures 15 and 16 a Patten tree in November, 1914, before and after pruning. Figure 17 is a Northwestern apple tree not yet pruned in 1914. It will be seen by reference to the figures showing the trees before pruning that the tops are not extremely dense, as at the time the photographs were taken (Nov. 11, 1914) a good deal of the foliage had dropped. When the pruning was begun in 1910, following three years of unrestricted growth, the tops of these trees were veritable heaps of brush. The pruning since 1910 has been directed primarily toward the gradual removal of superfluous wood. However, because of the fact that the trees were not well formed at the time they were planted and during the first year or two thereafter, the pruning in subsequent years has failed and must continue to fail to reduce the work to the simple, systematic operation that it is in the case of trees that are well pruned from the beginning. Most of the branches in these three trees (figs. 13, 15, and 17) are relatively long and slender because they radiate so largely from a common axis

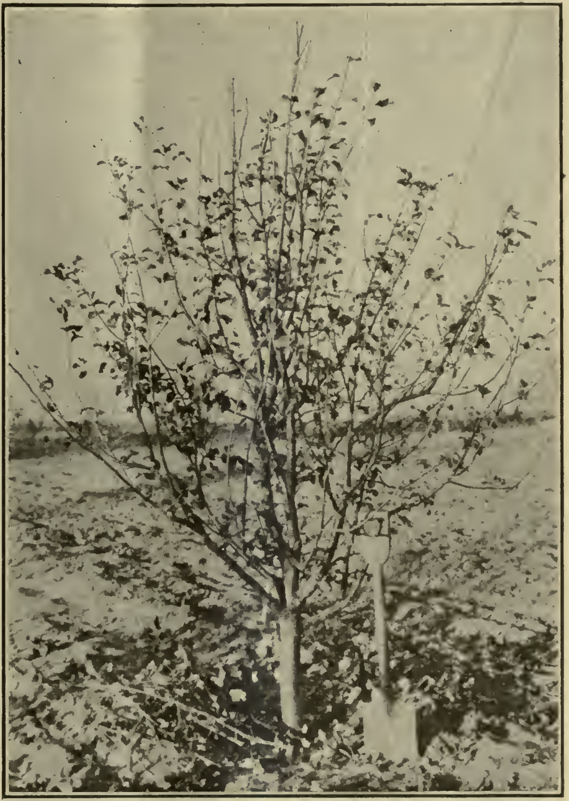
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FIG. 14.—The Wealthy apple tree shown in figure 13 after being pruned. Akron, Colo., November 11, 1914.

or from nearly a common center. To keep the tops suitably pruned is difficult. If one of the larger limbs with its component branches is removed to open the top, the result is an unsymmetrical head; one side is made considerably lighter than the other.

The alternative in maintaining the tops sufficiently open for the free access of sunshine and air is to cut away a considerable number of the smaller branches. This tends toward the development of long slender unbranched limbs, with the bearing surface a little later in the life of the trees occurring only near the extremities.

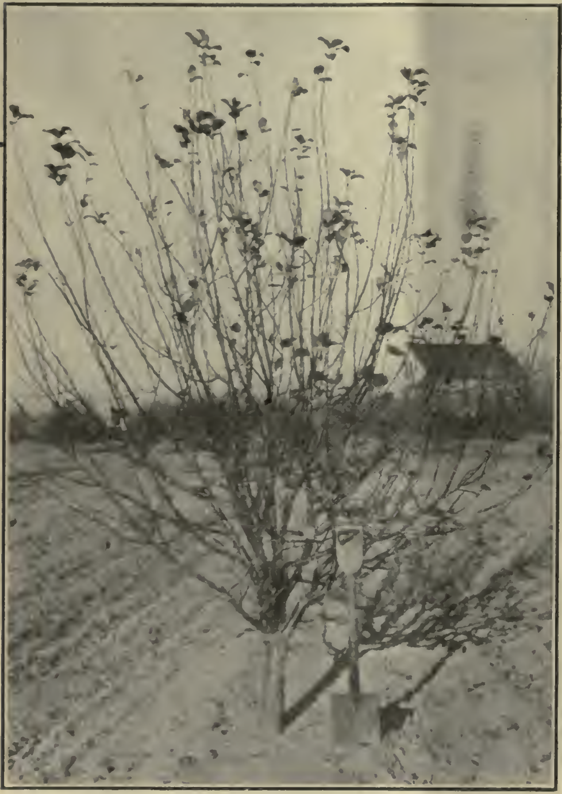
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FIG. 15.—A Patten apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in figure 13. Akron, Colo., November 11, 1914.

The point in question is especially evident in figure 17, where the tendency to make long, slender growth is very conspicuous, in spite of the effort made during the past three or four years to put the tree into the best shape that its condition has permitted.

A study of the illustrations here used emphasizes the fact, which all fruit growers recognize, that the natural habit of growth of different varieties must be considered in intelligent pruning. The upright habit of the Wealthy tree (figs. 13 and 14) and the roundish form of head shown by the Patten (figs. 15 and 16) and the Northwestern trees (fig. 17) make the problem of pruning these two types quite different in each case, even though the principles involved are the same. The Utter tree in figure 8 shows still another type of growth in that, even if left entirely unpruned, the top would not be likely to become as dense as that of the other varieties illustrated, because it does not branch so profusely. It is therefore less trouble to keep it well pruned, though the principles are the same as in pruning trees of the more profusely branching type.

The manner of pruning other fruit trees does not differ in principle from that followed with apple trees. Ordinarily the tops of plum and cherry trees are not kept quite as open as apples, principally because of the greater natural tendency to form fruit spurs along the branches; but if due attention is not given to the proper forming of the tops when planted and to wise pruning subsequently, the same troubles as those detailed for apples are sure to follow. This fact is made evident by figure 18, showing a native plum tree planted in 1908, as were the older apple trees referred to, which formed a head so dense that it was only with considerable difficulty that the fruit on the interior of the tree could be picked. Figure 19 is a De Soto plum tree that was planted in 1909. This variety does not make naturally as dense a growth as does the one in figure 18; besides, it was planted one year later, so that it began to receive systematic pruning that much earlier in its life. These plum trees have been headed back to some extent during the past three or four years, but they will not be likely to require very much more heading back.

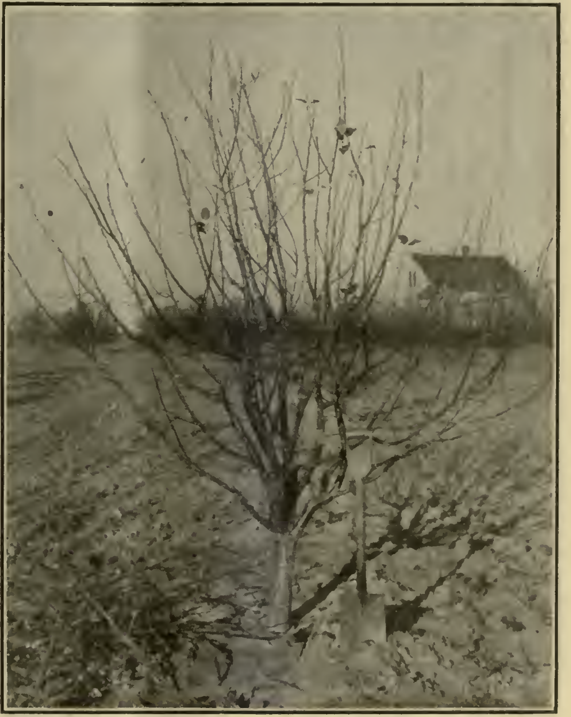
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FIG. 16.—The Patten apple tree shown in figure 15 after being pruned. Akron, Colo., November 11, 1914.

The Richmond cherry tree in figure 20 was also planted in 1909. It has responded fairly well to the corrective pruning that it has received during the past three or four years.

Another problem in pruning is suggested by the tree shown in figure 21. In some parts of the Great Plains area rather strong winds blow much of the time. The influence of such winds can be more or less checked as a rule by growing a well-arranged system of shelter belts that extend across the path of the prevailing winds. A little can be accomplished also by pruning. The branches should be kept well headed in. This heading in may need to be done during the growing season if a long, slender growth is being developed and it is being continuously forced far from its normal position. The top, if kept well opened, will offer less resistance to the wind than where it is allowed to become dense. Besides, if the tops are not too dense the branches will probably be less impeded in resuming their normal positions when the wind is not blowing. However, a complete counteracting of the influence of strong prevailing winds is hardly to be expected except as the force of the winds is broken by shelter belts of some kind.

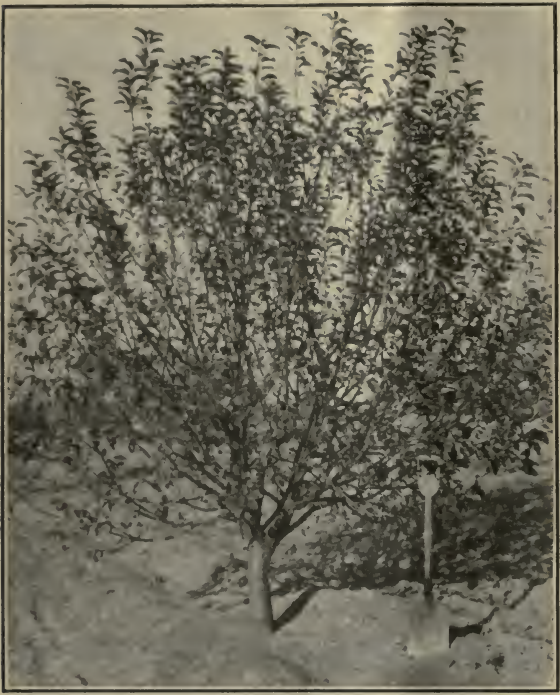
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FIG. 17.—A Northwestern apple tree planted in the spring of 1908, which has received treatment similar to that of the Wealthy apple tree shown in figure 13. This is the largest apple tree in the garden. Akron, Colo., November 11, 1914.

Great emphasis has been placed on pruning with a view to keeping the tops open. There are other reasons why systematic annual pruning should be done. Without regard to the order of relative importance, the more evident reasons may be enumerated as follows:

(1) Every branch is reaching out for sunlight. If the top is sufficiently open so that every leaf receives its full complement of sunshine there is less competition among the different branches than where the top is very dense.

(2) With the decreased struggle for existence among the branches, the crowding of the weaker ones and the resulting dead wood in the top of the tree are largely eliminated.

(3) The development of fruit-bearing spurs well within the center of the tree is encouraged because they receive sunlight, and sunlight in full measure is essential to healthy, vigorous growth.

(4) When a tree reaches bearing age it can be sprayed thoroughly, and it is evident that spraying will be necessary in this area if good fruit is to be

grown. Besides, the fruit can be picked with reasonable ease and comfort. But not so if the picker must crawl through a brush pile to reach it!

(5) The above reasons are common to all fruit-growing regions. Another is of special significance on the Great Plains because of the limited rainfall. The conservation of the moisture in the soil is of the greatest importance. Great quantities of moisture are taken up by a tree and given off through the foliage. In general, the greater the amount of foliage the more rapidly is moisture given off. By proper pruning and thereby the holding of the top to a form or condition as to the number of branches and the amount of foliage which are most consistent with the objects for which the tree is desired, the less will be the loss of moisture from the soil through the foliage. Hence, it follows that wise pruning helps to conserve soil moisture.

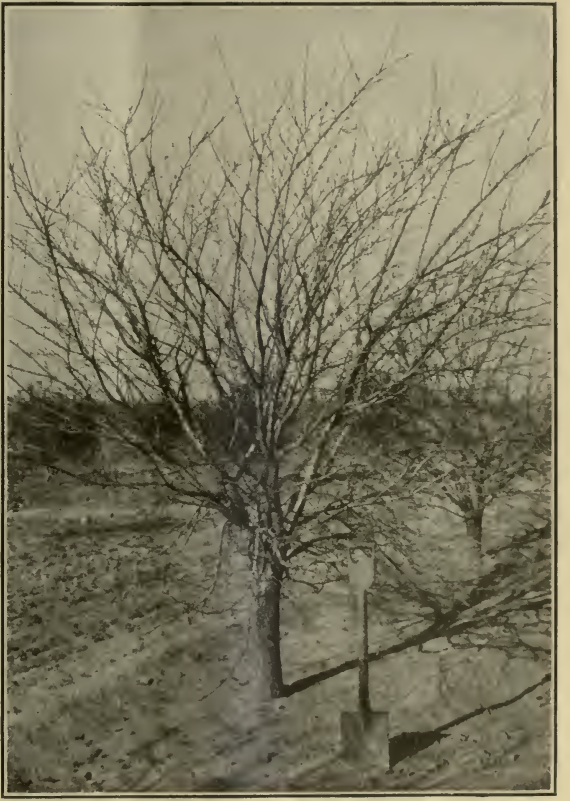

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FIG. 18.—A plum tree of unknown identity planted in the spring of 1908, which is the largest tree of any kind in the garden, though during 1914 the apple tree shown in figure 17 nearly overtook it. It has received treatment similar to the Wealthy apple tree shown in figure 13, but it is in better shape for a plum than the Wealthy is for an apple. Akron, Colo., November 11, 1914.

IRRIGATION.

While fruit growing on the average ranch in the Great Plains area must be largely under dry-farming methods, a relatively small quantity of water for irrigation may sometimes save fruit trees, and especially strawberries and other small-fruit plants, during a particularly dry period.

Wells of large capacity and windmills are to be found on many ranches and often furnish an adequate supply of water for use in tiding fruits over a crisis of drought. On other ranches a supply of water for emergency use is sometimes stored in earth reservoirs, as suggested in figure 22.

Such a reservoir is made by excavating the earth and mounding it up somewhat about the edge or rim. The inside is then puddled with clay or in some other way made sufficiently impervious to water to prevent seepage. Obviously, it should be located if possible on a slightly elevated site. It may be filled from the ranch well when the water is not required for other purposes, and the water may be siphoned out when wanted for irrigation.

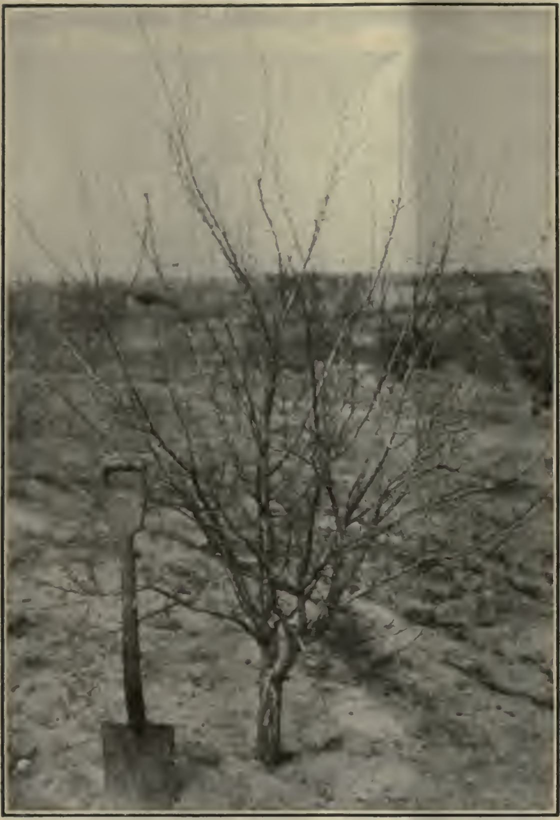

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FIG. 19.—A De Soto plum tree planted in the spring of 1909, which has received treatment similar to the other trees planted prior to 1911, but as its tendency to branch is less pronounced the top never became as dense as some of the other sorts. Akron, Colo., November 12, 1914.

ORCHARD PESTS.

The orchard pests in the Great Plains area are not known to be essentially different from those in other regions except as they are influenced by regional, primarily climatic, conditions.

On account of the comparative dryness of the atmosphere, fungous diseases are not as prevalent as in the humid regions, where conditions are more favorable for their development.

Insects, such as the codling moth and currant worm, may be expected to occur. It may be assumed that the methods of control that are effective in other regions will be equally effective in this area.

Rabbits are likely to injure young trees during the winter by gnawing the bark, and in some sections pocket gophers and prairie dogs may be troublesome. Information regarding the control of these pests can be obtained by addressing the Department of Agriculture.

Sun scald sometimes occurs during the winter on the south or southwest side of the trunks, especially in the case of high-headed trees. Injuries of this kind can be prevented by shading the trunks in some way during the winter. Binding laths, narrow strips of board, or cornstalks about the trunks, or even wrapping them with newspapers, will furnish all the protection needed. The material used should be removed in the spring.

HAIL INJURY.

On September 22, 1910, the trees in the Akron fruit garden were seriously injured by a hailstorm. The results may be of interest in connection with the handling of trees in other parts of this area which may be injured by hail. The oldest trees in the garden were completing their third season's growth when the storm occurred. The bark on the north side of the trunks and larger limbs of many of the trees was badly bruised, and in some instances practically torn from the trees. Nearly all varieties of apples and cherries sustained substantially the same degree of injury. There were several varieties of apples, however, that appeared as if by chance to escape in a slight degree, but it is hardly to be assumed that this was due to any greater resistance of these particular sorts to the hail. Most of the plum trees passed through this storm with relatively less injury than that received by the apple, pear, and cherry trees. The tops of the peach trees were practically killed.

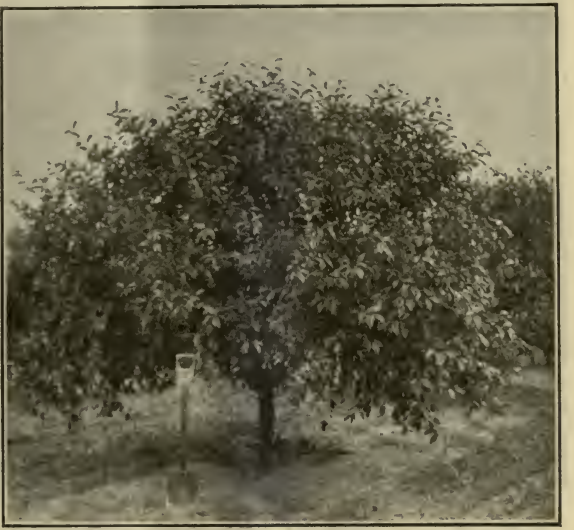

FIG. 20.—A Richmond cherry tree planted in the spring of 1909, an example of a tree that did not receive proper pruning and shaping of the top the first two years, but which has responded fairly well to corrective pruning during the past three or four years. Akron, Colo., July 20, 1915.

During the two years following this injury the tops of a good many of the apple trees died, and to some extent those of other kinds also. The seriousness of the wounds on the trunks became very evident. In many instances where the tops were injured beyond recovery, good, strong sprouts developed from some point along the trunks. The one best suited for renewing the top was selected and the original top cut away.

section. However, the behavior of the fruits in the garden at the Akron Field Station may be used to further the information concerning varieties in this part of the area, at least so far as the growth of the trees is concerned. Reference to the various illustrations in this bulletin showing apple trees in this garden will be of assistance in this connection.

Among the older trees in the garden, the following seem especially promising for this section: Yellow Transparent, Oldenburg, Wealthy, Northwestern, Patten, and the Hyslop crab.

A considerable number of other varieties have been planted during the past three or four years, including the Benoni, Delicious, Eastman, Jonathan, Livland, Longfield, McIntosh, Malinda, Okabena, Peerless, Peter, Plumb Cider, Stayman Winesap, Tolman, Utter, Whitney, and Windsor, and the Dartt, Lyman, Minnesota, and Transcendent crabs, all of which are making excellent growth.

All of these varieties appear to be sufficiently hardy to withstand the normal conditions in this region. But the real test of their value will come later when the trees reach bearing age and because of their larger size the soil-moisture requirements are greatly increased.

A number of dwarf apple trees were planted during the first year or two following the establishment of the garden. These include the Yellow Transparent, Oldenburg, Gravenstein, Wealthy, Bismarck, McIntosh, Esopus, and Northern Spy. Thus far these trees have done well, and their behavior is such as to make them seem rather promising. Dwarf apples can not be recommended for planting, however, until after they have more definitely demonstrated their value.

Northern section.—Naturally the varieties that can be planted in this part of the area must be restricted to the hardier sorts on account of the extremely low winter temperatures. These include the Oldenburg, Wealthy, Hibernal, McMahon, Northwestern, Patten, Malinda, the Hyslop crab, and possibly some others named in the Akron Field Station list for planting where the conditions are not too extreme. There are some localities in this section, however, where even the hardiest sorts would be of doubtful value.

PEARS.

There are hardly enough pears now growing in this area to show the range of their possibilities, unless their comparative absence is to be interpreted as signifying that they are not well adapted to these conditions. The Kieffer, Angouleme (*Duchess*), Bartlett, and possibly one or two other sorts are occasionally grown in the southern part of the area. A variety supposed to be the Warner has grown well at the Akron Field Station, but trees planted in 1908 have not yet matured fruit. The Flemish (*Flemish Beauty*) is one of the hardiest sorts and sometimes succeeds farther north than most other varieties

PEACHES.

Peach growing in this area is largely confined to the southern section, where a considerable number of varieties are grown to a limited extent. These include the Alexander, Sneed, Triumph, Arp, Carman, Mamie Ross, Chinese Cling, Elberta, Heath, Lee (*General Lee*), Lemon Cling, and others.

At the Akron Field Station peach trees, including a number of the hardier sorts, were killed to the ground, or nearly so, every winter.

PLUMS.

Plums, particularly the native sorts, are perhaps the most dependable of all the tree fruits for planting on the Great Plains. They have been planted quite widely throughout most of this area, and there is a fairly large number of varieties from which one may choose. Of these the following are named, especially for the southern sections: America, De Soto, Golden (*Gold* of Stark Bros.), Hammer, Kroh (*Poole's Pride*), Laire, Pottawattamie, Robinson, Roulette, Six Weeks, Surprise, Wayland, Whitaker, Wildgoose, Wolf, Wooten, and Wyant.

Among the more promising varieties at the Akron Field Station are the following: Brittlewood, Burwood, Cheney, De Soto, Hawkeye, Surprise, Terry, Wolf, and Wyant. The identity of the plum shown in figure 18 is unfortunately unknown, but it is one of the most promising sorts in the Akron garden. It resembles the Brittlewood somewhat and may prove to be that variety. Most of these varieties have been planted widely throughout the Great Plains area. Several varieties of European plums, including the Lombard, Arctic, Shropshire (*Damson*), and others, have also been planted at this station. None of them can be considered promising. The trees make only small growth as a rule, and they do not withstand the winter conditions in a satisfactory manner.

In parts of the northern section the following varieties are more or less grown: Cheney, De Soto, Forest Garden, Rollingstone, Surprise, Wolf, and Wyant.

CHERRIES.

Second only to the plums among the tree fruits for this area are sour cherries. The number of varieties commonly grown is small, the Richmond (*Early Richmond*), Montmorency, and English Morello comprising nearly all the trees that have been planted; in fact, there are probably to be found many times more trees of a single variety—the Montmorency—than of all the others combined. These varieties are successful generally in the central and southern sections, as well as in some parts of the northern section, but in the latter there are large regions where the conditions practically preclude the growing of cherries.

A Richmond cherry tree planted at the Akron Field Station in 1909 is shown in figure 20. Several trees of the Tartarian and other sweet cherries have also been planted at this station, but they have either died or are in an unsatisfactory condition. It is not believed that sweet cherries are likely to withstand the conditions anywhere in this area.

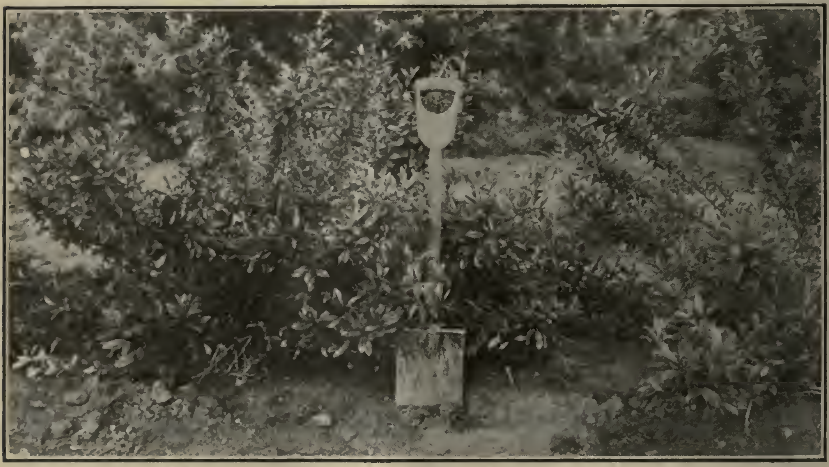

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FIG. 23.—Sand cherries planted in the spring of 1911, fruiting heavily in 1913. Akron, Colo., July 19, 1913.

Sand cherries also do well in many parts of the Great Plains area. The ones shown in figure 23 were planted in 1911 and fruited in 1913. The fruit is of value primarily for making jelly or preserves rather than for use in the fresh state. But as the sand cherry is native to the Great Plains, doubtless selections could be made which would bear fruit of fairly good edible quality.

SAND CHERRY-PLUM HYBRIDS.

Of this type of fruit the Compass cherry, a hybrid between the sand cherry and the Miner plum, is the only variety that has been widely planted as yet in this area. It is proving to be of distinct value. Trees planted at the Akron Field Station in 1910 began bearing in 1912 and produced good crops in 1913 and 1914. Though not of high quality, the fruit is very acceptable. The tree comes into bearing early and seems to be perfectly hardy here. Figure 24 shows a Compass tree, planted in 1910, as it appeared in November, 1914. The tree makes a very open growth; practically no thinning out of branches has been done in the tree shown here.

A number of other varieties of the same general type have been developed and are now being planted more or less. They are promising for the Great Plains area generally, being very hardy and seemingly well adapted to the conditions under which many other fruits fail. The Opata, Sapa, and Hanska are representative varieties of the new hybrids in this group.

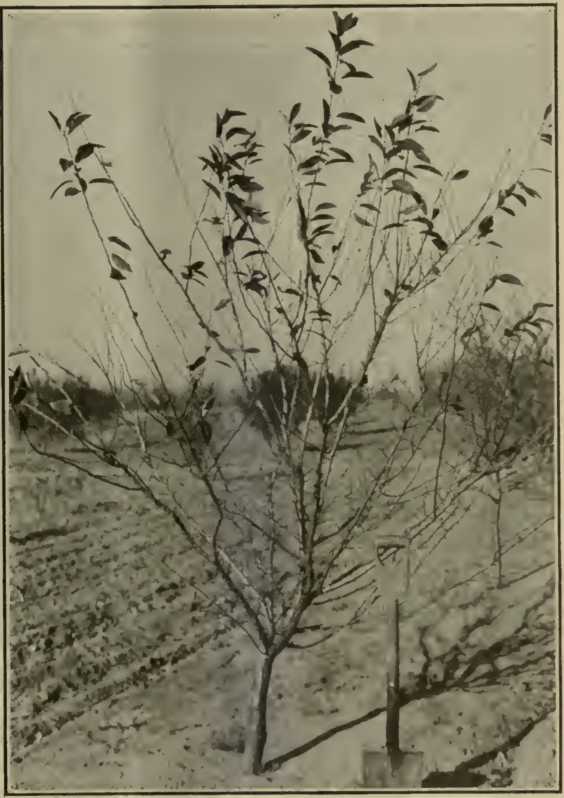

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FIG. 24.—A Compass cherry planted in 1910. The open, spreading habit of growth is to be noted. Akron, Colo., November 11, 1914.

CURRANTS.

Currants appear to be one of the most satisfactory small fruits for the Great Plains. Most varieties do about equally well and are generally hardy. The London (*London Market*) is perhaps grown in larger quantities than any other sort, but the Cherry, Victoria, Red Dutch, and North Star, for red sorts, and the White Grape, for a white variety, have done well at the Akron Field Station and include the sorts most commonly found elsewhere in the Great Plains area.

The plants as a rule are a little slow the first year in getting started, but when well established they make a good growth if properly pruned. Figure 25 shows some currant bushes planted in 1909 or 1910 which are quite typical in growth of all the varieties at the Akron Field Station.

GOOSEBERRIES.

In general, what has been stated regarding currants is true also of gooseberries. They are quite dependable wherever currants are succeeding.

As in the case of the latter, the plants are a little slow in getting established and do not often make a very strong growth the first season. After they are once well established, they appear to be hardy. To keep them vigorous, however, the sprouts that habitually grow from the ground in rather large numbers should be kept well thinned out.

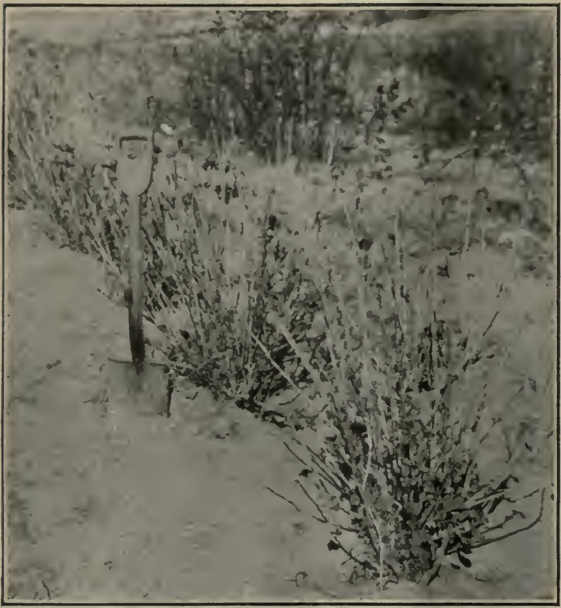

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FIG. 25.—Currant bushes planted about 1910, showing typical growth. Akron, Colo., November 11, 1914.

Probably the Downing, Houghton, and Poorman can be planted generally in this area with as much assurance of satisfaction as any other varieties.

RASPBERRIES, BLACKBERRIES, AND DEWBERRIES.

Raspberries, blackberries, and dewberries have not proved very successful in this area, and they have not been planted as a rule in the ranch fruit gardens. Generally speaking, they do not withstand dry weather well. Even in the humid sections heavy losses sometimes occur as a result of drought.

In many instances in this area the plants are slow in starting growth after being set out, though when once established the roots are quite persistent. The canes, however, are very apt to kill to the ground during the winter. To some extent winter injury can be prevented by bending the canes to the ground and covering them with soil, but how widely this method of winter protection can be used successfully is not definitely known.

Of the varieties observed in this area there seems to be but little, if any, real preference, as there has been no important difference in their behavior. Of the raspberries, the Cuthbert, Loudon, King, and

Sunbeam, for red sorts, and the Cumberland, Kansas, and Winfield, for black varieties, have been planted at the Akron Field Station. They have all borne a little fruit; possibly the Sunbeam has done fully as well as any variety. The canes of all varieties have winter-killed so badly that there is little choice for planting. No winter protection, however, has been given them.

Blackberries at the Akron Field Station have behaved in essentially the same manner as the raspberries. They are rather slow to start into growth after planting. The canes have been killed back to the ground, or nearly so, every winter, and practically no fruit has been produced. The Himalaya—a variety the canes of which are perennial and normally do not die after producing a crop of fruit, as do the ordinary varieties, and which has been considerably exploited for general planting—has made a fairly strong growth each year. However, it is not hardy enough to withstand the winters, though it does not usually kill back as far as do the other sorts. It has produced a very small quantity of fruit, which ripens over a long period, and only a few fruits are ever ripe at the same time, even on 10 or 12 large plants. The berries are small and imperfect, merest nubbins, and the proportion of seed to pulp is so large as to make the fruit almost inedible. Besides the Himalaya, the Snyder, Mersereau, and Rathbun varieties have been planted, none of which seem to be promising for this area.

Only one variety of dewberry, the Lucretia, has been planted. This bore a little fruit in 1912, but in general its behavior has been the same as that of the raspberries and blackberries.

It is probable that much of the winter injury to these fruits is due to the limited moisture supply rather than to the direct effect of low temperatures, especially in the southern and central sections. In the northern part of this area extreme cold is doubtless a limiting factor in itself, except where the plants are adequately protected. To the extent that the difficulty is a matter of moisture, proper irrigation before the ground freezes in the late fall might be of considerable importance.

STRAWBERRIES.

Success with strawberries in this area seems to be more largely a matter of the plants becoming well established and having an adequate moisture supply during certain periods than in the planting of any particular variety; in fact, the establishment of the plants is usually dependent upon a suitable amount of moisture in the soil. The roots are so near the top of the ground, at least until after growth has been well renewed, that they are very susceptible to the surface conditions of the soil. The roots of strawberries may dry out completely before a new growth starts, where other kinds of plants with their roots deeper in the soil would not be seriously affected. Hence, if newly set plants can be watered as needed until they are well reestablished after transplanting, the chief danger of failure in the beginning is eliminated. Unless this can be done, the plants will die in many cases before a new growth starts.

It is also important that water be available for use during the development of the fruit. At this period the strawberry requires a relatively large quantity of water. If it is lacking, the fruit will be small and much of it may fail to develop.

By mulching with straw during the winter to prevent repeated thawing and freezing as well as to protect the plants from extreme temperatures, strawberries can probably be grown almost anywhere in the Great Plains, provided water can be applied during the critical periods mentioned.

While irrigation might be quite advantageous at times in the growing of other fruits, it may often be practicable to water a small strawberry bed that can be located near the dwelling house, when it would be out of the question to water a fruit garden more or less distant from the buildings.

As to varieties, the Excelsior, Bederwood, Crescent, and Dunlap are suggested. Of these, the Crescent is the only one that has imperfect flowers; it must therefore be planted with a perfect flowering sort in order to produce fruit.

JUNE BERRIES.

Not many June berries have been planted in this area. As a rule they do not make a very vigorous growth, but appear to be hardy when well established and may be expected to bear considerable fruit. The fruit, while not of high quality, will add an agreeable variety for home use.

BUFFALO BERRIES.

Of the wild fruits that are native to this area the buffalo berry is worth consideration, especially for the northern sections, where the range of fruits that can be grown is more limited than in other parts of the area. The fruit is small and quite sharply acid. Its most important use is probably for making jelly, though it is eaten in the fresh state to a limited extent.

The fruit-producing blossoms are borne on separate plants from those that bear the pollen-producing blossoms. As only the former bear fruit, bushes for planting should be largely of that type, though a small proportion of the others must also be planted to supply pollen for the fertilization of the fruit-producing blossoms.

GRAPES.

There is very little definite knowledge concerning the possibilities of grape growing in this area. Low temperatures in the north are largely prohibitive, but in some parts of the other sections it is probable that a measurable degree of success could be secured, especially in localities where wild grapevines are found. The following varieties, among others, have been tried to a limited extent in this area: Beacon, Beta, Captain, Carman, Concord, Fern Munson, Headlight, Herbemont, Janesville, Lenoir, Marguerite, R. W. Munson. However, no special recommendations or suggestions as to their adaptability to any part of the Great Plains can be made at this time.

MIXED PLANTING ADVISABLE.

Attention should here be called to the fact that many varieties of apples, plums, pears, cherries, and other fruits are more or less sterile with their own pollen. Such varieties, therefore, may be unfruitful, even though they blossom abundantly, unless planted in close proximity to other varieties of the same kind which blossom simultaneously with them. While not all varieties are self-sterile, and sometimes those which are so under certain conditions are not self-sterile under others, the matter is of too great importance to be disregarded when planting orchards or fruit gardens. It is therefore always wise to select at least two varieties of each kind of fruit for planting, unless one has good evidence that under his conditions a variety which he desires is self-fertile.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO FRUIT GROWING THAT MAY BE OF USE IN THE GREAT PLAINS AREA.

AVAILABLE FOR FREE DISTRIBUTION.

The Apple and How to Grow It. (Farmers' Bulletin 113.)

The Home Fruit Garden: Preparation and Care. (Farmers' Bulletin 154.)

The Propagation of Plants. (Farmers' Bulletin 157.)

Pruning. (Farmers' Bulletin 181.)

Strawberries. (Farmers' Bulletin 198.)

Raspberries. (Farmers' Bulletin 213.)

Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio. (Farmers' Bulletin 440.)

The information in this bulletin may be applied also to spraying plums and cherries.

Grape Propagation, Pruning, and Training. (Farmers' Bulletin 471.)

The Pear and How to Grow It. (Farmers' Bulletin 482.)

The More Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple. (Farmers' Bulletin 492.)

Growing Peaches: Sites, Propagation, Planting, Tillage, and Maintenance of Soil Fertility. (Farmers' Bulletin 631.)

Growing Peaches: Pruning, Renewal of Tops, Thinning, Interplanted Crops, and Special Practices. (Farmers' Bulletin 632.)

These bulletins on growing peaches (Nos. 631 and 632) are of value in this connection primarily because of the discussions concerning planting, tillage, pruning, etc., which are applicable generally to fruit growing, from the standpoint of the fundamental principles involved.

Blackberry Culture. (Farmers' Bulletin 643.)

Field Mice as Farm and Orchard Pests. (Farmers' Bulletin 670.)

The Roundheaded Apple-Tree Borer. (Farmers' Bulletin 675.)

Cottontail Rabbits in Relation to Trees and Farm Crops. (Farmers' Bulletin 702.)

Bridge Grafting of Fruit Trees. (Farmers' Bulletin 710.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

Fruit Growing for Home Use in the Central and Southern Great Plains. (Bureau of Plant Industry Circular 51.) Price 5 cents.

This circular is superseded by the present publication.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 728 JUNE 12, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

DEWBERRY CULTURE.

By GEORGE M. DARROW,

Scientific Assistant, Office of Horticultural and Pomological Investigations.

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INTRODUCTION.

The dewberry is closely related to the blackberry, having a root that lives for many years and a top that lives only two years. Like the blackberry, it bears fruit upon last year's canes, which die soon after they have fruited. It is distinguished from the blackberry in having canes that trail on the ground, while those of most blackberries are upright. From this habit it receives the name "trailing blackberry," which is commonly applied to it. In the wild state the canes of the dewberry form new plants by rooting at the tips, while blackberries propagate themselves by suckers. Further, the center flower in a dewberry cluster blossoms first, and the clusters are small and open, while in the blackberry cluster the outer and lower flowers open first and the clusters are usually rather dense. Figure 1 shows this difference between the fruit clusters.

The fruit of the dewberry is similar to that of the blackberry. Because it ripens earlier than the fruit of the true blackberry its culture has proved profitable in many sections. Recently some hybrids between the dewberry and the blackberry have come into cultivation, and the fruit of some of these ripens even earlier than that of the dewberry. These hybrids have not been sufficiently tested to indicate their entire range of adaptability, but in some places they have proved valuable.

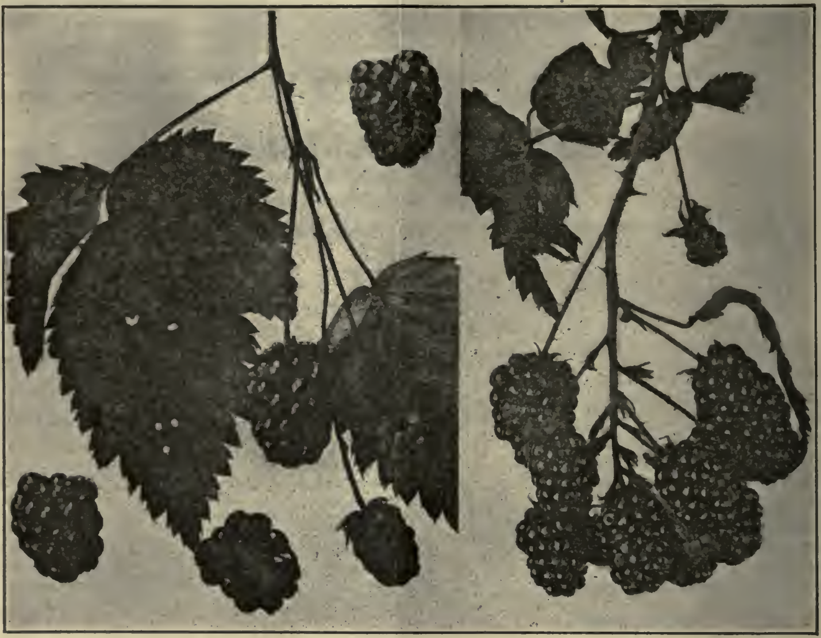

FIG. 1.—A cluster of Mayes dewberries, on the left, and of Mersereau blackberries, on the right. Note the small cluster of the Mayes dewberry, with its long berry stems, as compared with the larger and denser cluster of the Mersereau blackberry.

HISTORY OF THE DEWBERRY.

The dewberry is a native of America, and all varieties are of American origin. The Lucretia was the first to be introduced into general cultivation and is to-day the principal variety grown. It was found in West Virginia soon after the Civil War and brought to general notice about 1886. Since then many other varieties have been introduced, and at present about 25 are to be found under cultivation, none of which is as popular as the Lucretia.

The two States in which the dewberry is grown extensively on a commercial scale are North Carolina and New Jersey. It is also grown in Maryland, Texas, Missouri, Michigan, Colorado, and to some extent in most of the other States. The Lucretia variety, although the one chiefly grown, is not very hardy, and for this reason its culture has been confined in the past to the milder climates. Recently it has been grown more in the Northern States and in Colorado and is proving profitable in favorable locations or when protected from severe winter conditions.

SITE OF A PLANTATION.

In regions where winter conditions are severe, the site for a dewberry plantation should be as well protected as possible from cold and from winds. In order to secure good air drainage, a site elevated above the surrounding country is preferred to low ground. However, it should not be exposed to drying winds or to other trying conditions.

Long hauls by wagons and jolting over rough roads will bruise the berries so they will not hold up well on the market. Therefore, the plantation should be as near local markets or a shipping station as possible.

SOILS.

The cultivated dewberry is grown on many types of soil. In its wild state it is found in open fields and pastures and by roadsides, especially where the soil is poor and the growth of grass and herbage is thin. In such locations its leaves can get more sunlight than where the soil is rich and the grass rank. Though the plants will grow on poor land, it is necessary in order to produce good crops of fruit that it be fertile or that plant food be supplied. In North Carolina the soil in many of the large dewberry fields is a coarse sand. Fertilizers are applied liberally to plantations on such soils. In other sections clay loams and other soils are used for dewberry fields, and if they are fertile less plant food need be added. As the dewberry has a very deep root, it is able to get moisture from a considerable depth and is, therefore, not as particular in its requirements as many other plants.

Dewberries should not be set on wet soil. Because of their deep rooting system they are more susceptible than many other fruits to wet soils. In some sections root-rot has been found to kill plants where the soil was only slightly wet; on the other hand, the soil must furnish a sufficient moisture supply, especially at the time the berries are developing and ripening. Coarse sandy loams with a clay subsoil have proved a desirable type in one dewberry section. Any fertile soil provided with good drainage and yet with a good supply of humus to retain moisture is suitable for growing dewberries.

PREPARATION OF THE SOIL.

As the dewberry plants are to occupy the soil for several years the land should be very thoroughly fitted before they are set out. If the soil lacks humus, the use of cover crops before planting dewberries will be helpful. Much better results will be secured if the land is planted to cultivated crops for two years prior to setting it to dewberries. The plants will grow better the first year, and a crop will be secured earlier than without such preparation. Usually very little fruit is obtained the year after planting, yet figure 2 shows a plantation set the previous year which was yielding a good crop. This field had been carefully prepared before the plants were set.

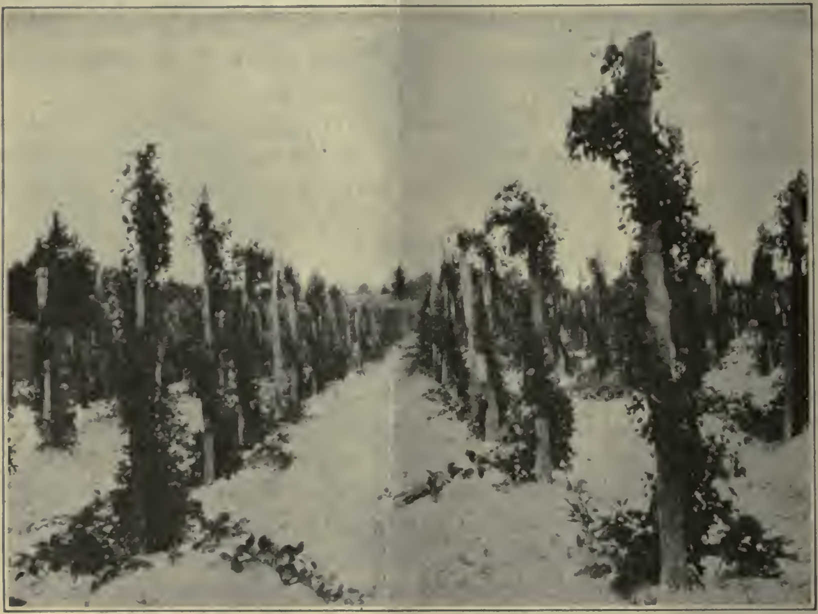
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FIG. 2.—A field of Lucretia dewberries in North Carolina bearing a good crop the year after planting. (Photographed June 12.)

PLANTING.

Dewberry plants are usually set during the winter and early spring in the South and in early spring in the North. More mature plants are secured for setting in the spring than in the fall. Figure 3 shows strong Lucretia dewberry plants ready to be set. Because the essential factor of success in planting dewberries is a moist soil, they should be set as early in the spring as possible, for there is usually more moisture in the ground at that time than later and a larger percentage of the plants will live.

The plants should be set as soon as possible after being received from a nursery or after being dug. Exposure of the roots to the air dries and weakens them. When planting, the soil should be thoroughly packed about the roots. Thorough packing brings the soil moisture in contact with the roots and prevents the air from drying them.

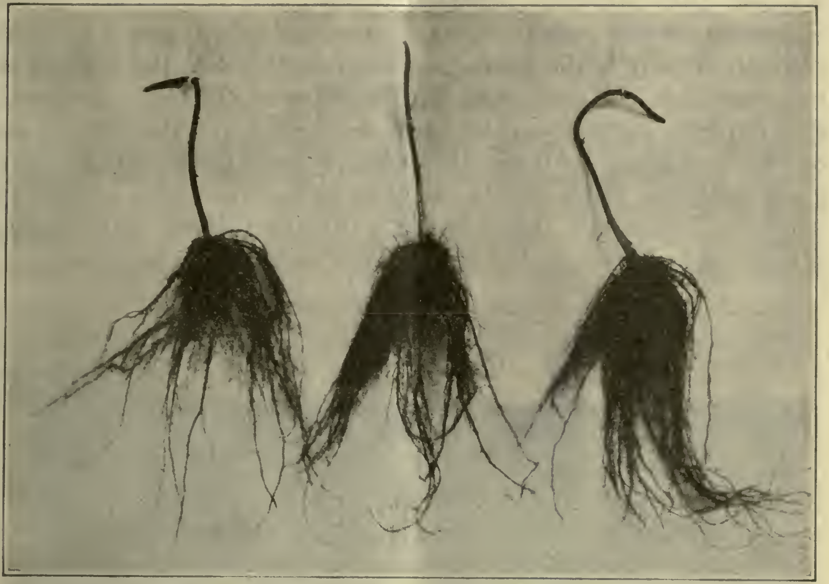
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Fig. 3.—Tip-rooted Lucretia dewberry plants ready to be set.

If the hill system of training is to be used, the plants are usually set 5 feet apart each way. Figure 4 shows a field in which the canes are to be trained to stakes after the plants have made several months' growth. If the canes are to be trained in solid rows the plants are

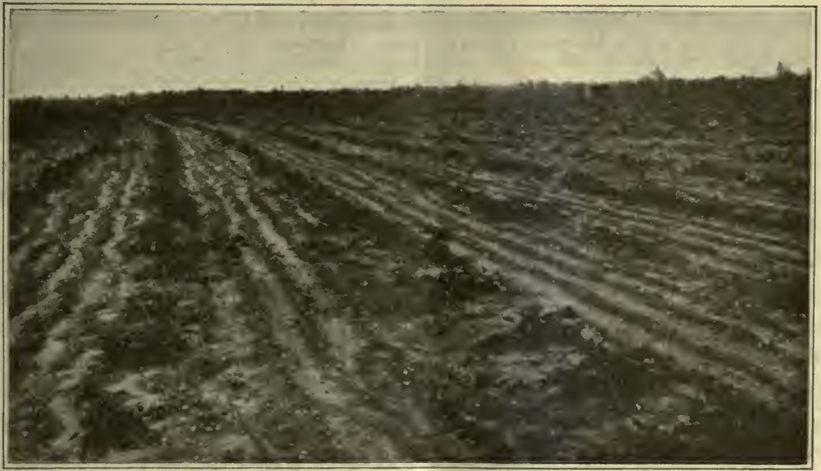
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Fig. 4.—A field of Lucretia dewberries in New Jersey in their first season's growth, following spring planting. (Photographed July 30.)

usually set 3 feet apart in rows which are 4 to 6 feet apart. Figure 5 shows such a field.

INTERCROPS.

During the first season vegetable intercrops that require frequent cultivation early in the season may be grown between the rows. Lettuce, radishes, early cabbage, and cauliflower are well adapted to this purpose, as they can be harvested before the dewberry canes become very long. If the soil has been properly fitted and the plants grow well, the canes should begin to spread over the ground by August. Intercrops that require cultivation later than August should not be grown, as the young canes are likely to be injured.

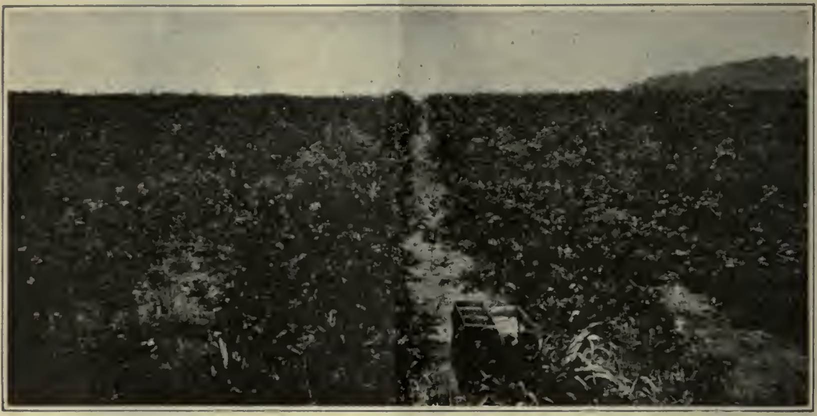
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FIG. 5.—A field of Mayes dewberries in Tennessee trained to the matted-row system, with a low wire under the row. (Photographed May 9.)

CULTIVATION.

Cultivation should begin immediately after the plants are set. In some sections cultivation should be as frequent as once each week during the first season, in order to keep the ground moist and the plantation free from weeds. In others, such frequent cultivation will not be necessary, once every 10 days being sufficient. When the canes which are allowed to trail on the ground the first year begin to interfere, cultivation should be discontinued, and nothing further should be done in the field until the following spring except in sections where winter protection is necessary. Any work during the autumn or winter is likely to injure the young canes. If they are bruised, they may break off at the bruised point in the next fruiting season and the fruit be lost. Therefore caution should be used at all times, as not only in the fall but at any time during the following spring and summer serious damage may be done by carelessness. The canes become very brittle and when loaded with fruit are very easily broken.

In most sections the canes are tied to stakes or wires before growth starts in the spring. Cultivation should be started immediately after growth begins and continued at frequent intervals until the new canes begin to interfere with cultivation, which is usually some time in August.

COVER CROPS.

At the last cultivation some growers sow a cover crop broadcast in the plantation, to be turned under the following spring. Others, in sections where cowpeas are used, drill one or two rows of these between the rows of the berry plants. Wherever possible cover crops should be used, as they help to protect the canes during the winter, prevent the land from washing, and add humus to the soil. If cowpeas are used and the vines grow very long, they may increase the expense of tying up the canes in spring, but the value of the cover crop will more than offset this.

FERTILIZERS.

The use of fertilizers in dewberry fields must be governed by the same principles that apply to their use with other fruits. As soils vary in the quantity and availability of the plant food they contain, the fertilizer problem is a local one which each grower must solve for himself. By using varying amounts of the different elements of plant food on different plats and keeping a record of the yield, each grower can readily determine what kinds and quantities of fertilizers to apply.

In one section of North Carolina dewberries are grown on coarse sandy soils. These soils as a rule are lacking in all the elements of fertility, and the application of a complete fertilizer is usually necessary. Although larger amounts of fertilizer are applied than may be generally necessary, the following description of the practices of successful growers in this section may prove of interest.

As soon as the plants have become established and are 2 or 3 inches high, cottonseed meal or stable manure is used to encourage a vigorous growth the first season. Some growers use about 500 pounds of cottonseed meal, while others use 10 to 15 tons of stable manure per acre.

After the first season two applications of fertilizer are given each year, the first one being made as soon as the canes have been tied up in the spring. At this time a complete fertilizer is usually applied, composed of 10 per cent of phosphoric acid, 2 or 3 per cent of nitrogen, and 8 per cent of potash. Some growers, having found that they do not need nitrogen for their soils, apply only potash and phosphoric acid. The quantity applied likewise varies with the soil and with the different growers, but 500 pounds per acre of a fertilizer analyzing 10–2–8 are commonly used.

The second application of fertilizer is made immediately after the fruit has been picked and all the canes, both old and new, are cut off, the object being to induce a rapid growth of vigorous new canes for the next year's crop. A fertilizer containing a large amount of nitrogen is used at this time. Either stable manure or cottonseed meal is commonly used. An application of 500 to 600 pounds of cottonseed meal per acre is considered sufficient, although there are growers using as much as 1,000 pounds. Growers using stable manure consider an application of 10 to 20 tons per acre sufficient. In addition to supplying nitrogen, stable manure adds large amounts of humus to the soil and is preferred when it can be readily secured.

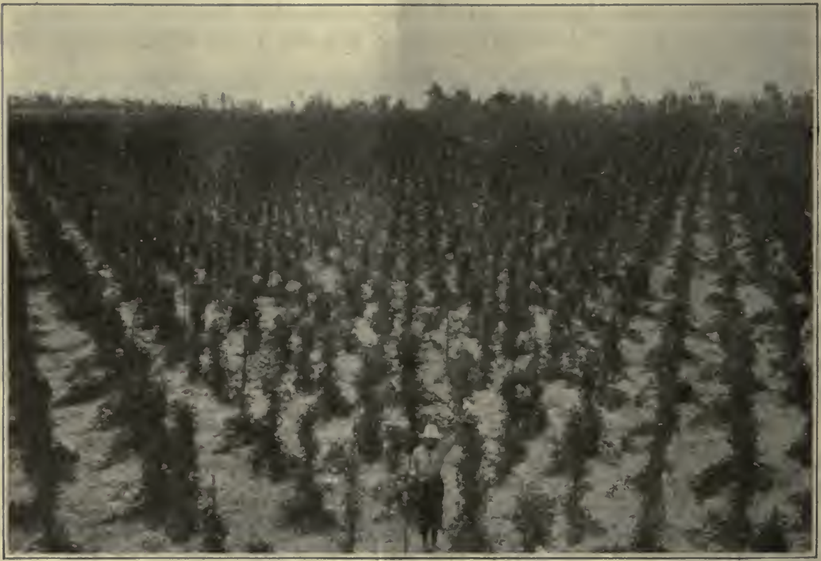
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FIG. 6.—A Lucretia dewberry field in North Carolina with the plants set 5 by 5 feet apart and the canes trained to stakes. (Photographed June 11.)

The practices mentioned above are those used by successful growers in North Carolina, and should prove helpful to growers in other sections in determining the applications for use under their particular conditions.

SYSTEMS OF TRAINING AND PRUNING.

The system of training to be used depends upon the climate, the cost of materials, and individual preference. In general, where suitable stakes can be secured for a reasonable price, the system of placing one at each hill and tying the canes to it will be most satisfactory; but in sections where stakes are very expensive some cheaper method must be used. Figure 6 shows a field with the plants 5 feet distant in rows 5 feet apart and a stake driven beside each plant. Under this system the plants are farther apart than under other systems. The expense of cultivation will be less, as more can be done with horse labor and very little hand hoeing will be needed. Picking will be much easier than under most other systems and fewer berries will be lost.

Under North Carolina conditions, where the canes grow vigorously, the stakes should be from 7 to 7½ feet long. There the stakes are made from yellow pine and are about 2 by 3 inches in size. In other sections stakes of any wood that will not decay quickly in the ground are used. These stakes, placed about 3 inches to one side of the plant, are driven about 2 feet into the ground. The canes are tied to the stakes in early spring. This is done before growth starts, but after danger of severe freezing weather is past. Gloves are used in gathering the canes in a bundle and winding them around the stake in a spiral, as shown in figure 2. The canes are tied to the stake in two or three places, once at the top, and either once more half way up the stake or in two places distributed along the stake. Soft string must be used for this tying, as a small, hard string is likely to break the canes. The ends of the canes are cut off about 6 inches beyond the upper tying.

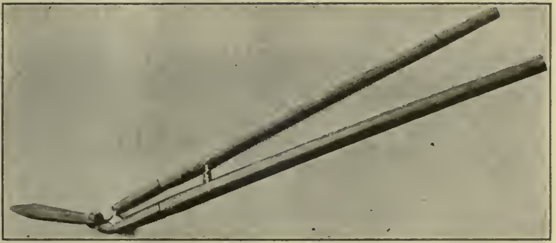
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FIG. 7.—Long-handled shears used in North Carolina for pruning dewberries. The steel blades are curved upward, thus enabling the pruner to cut the canes close to the crown without much stooping.

In North Carolina and in other States having a similar growing season, all the canes, both old and new, are cut off as close to the crown of the plant as possible immediately after the fruit has been picked. Figure 7 shows a tool used for this purpose. If there is a severe drought this cutting should be delayed till after a rain. The canes are removed from the field and usually burned. After they have been removed cultivation should start at once and be continued until the new canes begin to interfere. This will induce a vigorous new growth, on which the fruit for the following year will be borne. The new canes are allowed to run on the ground and are left there until the next spring, when they are tied to stakes in the same manner as the previous year's growth.

Sometimes, instead of single plants 5 feet distant two plants are used. These are set about a foot apart and a stake is driven into the ground between them, the canes of both plants being trained to it. This method of planting offers no advantages over a field with one plant beside each stake, provided such a field is properly treated.

Another similar system is shown in figure 8, where the plants are set 3 feet apart in rows 5 feet apart. More plants are used to the acre by this method, and the yields recorded for such fields have been very much less than for the system where the plants are set 5 feet apart each way. More hand labor also is required under this system, and the training, though like that in the system described, is more difficult.

Still another method is illustrated in figure 9. Under this system the plants are usually set 3 feet apart in rows 6 feet apart. A stake projecting about 3 feet above the ground is set half way between two plants. In the Central West the canes from each of the two hills are brought directly to the top of the stake, the canes from one hill tied to those from the other, and both sets of canes tied to the top of the stake. On the Pacific coast a stiff curved wire is sometimes used to help support the canes. One end of the wire is placed in one hill. It is curved over the top of the stake and fastened to it and the other end is placed in the second hill. The canes from each hill are wound around this wire before being tied to the end of the stake. This system of tying the canes from two hills to one stake seems especially adapted to regions where the canes do not grow very long.

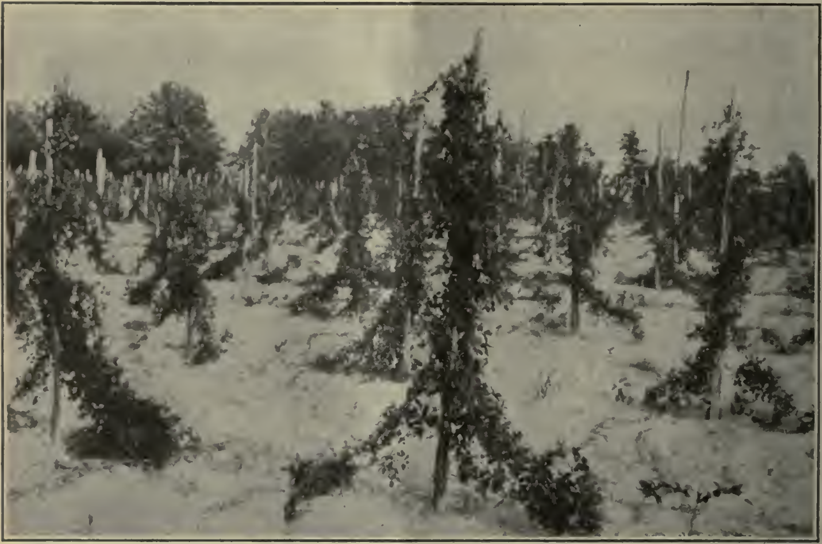

FIG. 8.—A Lucretia dewberry field in North Carolina, showing plants set 3 feet apart in rows 5 feet apart and the canes from two plants trained to one stake. (Photographed June 8.)

Where stakes are expensive a wire trellis is often used. The plants are set about 3 feet apart in rows 6 feet apart. Posts are set along the row, from 20 to 40 feet apart, depending on their strength and the vigor of the canes. The posts project about 4 feet above the ground, and a wire about 3½ feet above the ground is stretched along them. The canes are gathered together in a bunch and tied to the wire, as shown in figure 10. In Michigan the ends are commonly cut off just above the wire. In some places, however, the ends are tied along the wire and left to bear fruit.

In some regions a trellis is made with two wires. The posts are set about 5½ feet high and the wires are strung one above the other, about 3 and 5 feet above the ground. The canes are tied to the wires, part along the upper wire and part along the lower. This method is rarely used except on the Pacific coast.

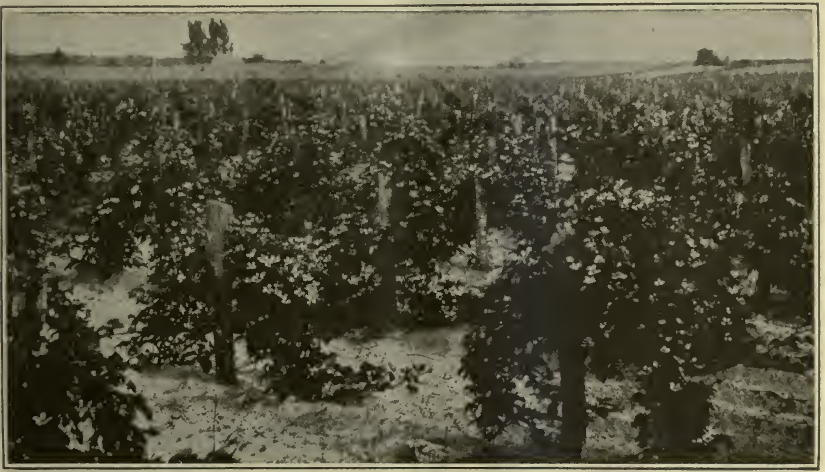

FIG. 9.—A field of dewberry plants in eastern Maryland trained to posts. The canes of two plants are tied to the top of one post. (Photographed May 26.)

In other regions neither stakes nor a wire trellis are used. The plants are set from 18 to 36 inches apart in rows 4 to 6 feet apart. Throughout the summer the plants are cultivated in one direction only. The tips are usually allowed to root at will along the row, but not between the rows. In Texas, where this system is used, it is necessary before picking to go over the plantation with a sickle or knife to cut the new canes back. The canes interfere with the pickers, and the cutting back does not injure the plants. After the crop has been harvested the canes are mowed as close to the ground as is possible with a machine. When dry they are burned without being removed from the field. This cleans the field of diseases and insects that may be on the canes, besides saving the cost of removing the old canes. The fields are then cultivated during the remainder of the summer and the new canes are allowed to make a solid row. Occasionally in Texas a plow is used to cut off all the plants just below the crowns. This removes all diseases and insects in the crowns and the new canes spring directly from the roots. These canes will not be as strong as those from the crown, but will bear a good crop the following year and a full one the second year. In Texas many dewberry fields when trained in this manner are mulched during the winter or spring with prairie hay. The berries are borne so near the ground that a thick layer of this hay is needed between the rows to protect both the pickers and the berries from the soil in case of rain. It also helps to conserve the moisture. After picking is over the hay can be placed on the rows to help burn the old canes. Sometimes as the new canes come up, the ends are pinched back so they will form a small much-branched bush.

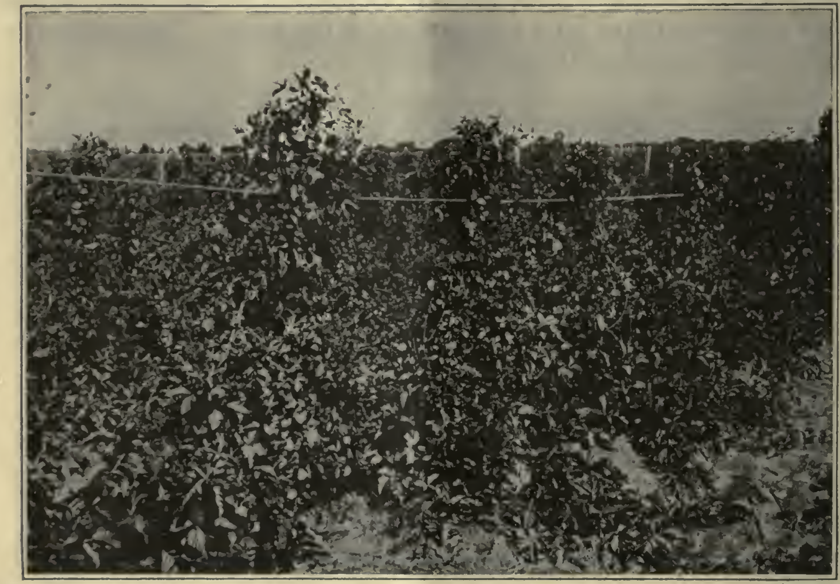

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FIG. 10.—A Lucretia dewberry field in southwestern Michigan. The bearing canes of each plant have been tied to the wire in a bunch and the ends cut off about 6 inches above the wire. (Photographed July 9.)

In Colorado no trellis is used and the plants are trained in rows. When the young canes reach a height of about 18 inches they are cut back to about 12 inches, to force the laterals to start. Just before picking, the laterals are shortened to enable the pickers to get the berries easily. No further pruning is done until the following spring, when the old canes are removed and the younger ones shortened to about 3½ feet. Under this system clean picking is difficult and many soft berries are liable to be put into the baskets, as the fruit is often partially concealed by the foliage.

Variations of this system are in use. Stakes projecting about a foot above the ground are set about 10 feet apart along the row, with a wire strung on the tops of them, and the canes are thrown over the wire. Sometimes two rows of stakes about 12 inches apart, with wires as in the single row of stakes, are used. The canes are simply allowed to grow over the wires.

WINTER PROTECTION.

In the Southern States, and in most of those States where snow covers the ground through the winter, no protection of the canes is necessary, as they trail close to the ground. In some parts of the Central Western and Northern States the canes must be protected during the winter. This is usually accomplished by covering the canes with 2 or 3 inches of earth. If the plants are in solid rows this can be done very cheaply by turning a furrow about 3 inches deep on the plants. The canes should be covered before there is danger of hard freezes and uncovered in the spring after the danger of freezing is past.

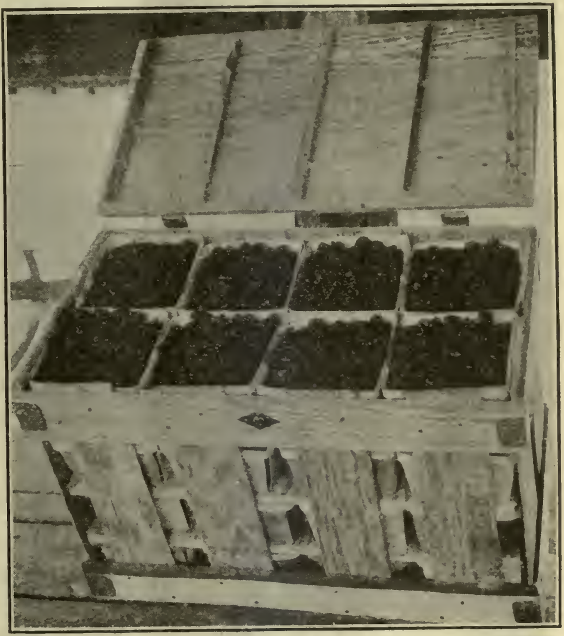
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Fig. 11.—A 32-quart crate of Lucretia dewberries grown in North Carolina. (Photographed June 11.)

HARVESTING.

Dewberries are picked and handled in the same manner as blackberries. They are usually picked in quart baskets and sent to market in crates holding either 24 or 32 baskets. Figure 11 shows a crate of Lucretia dewberries. The same care should be observed in handling dewberries as in handling blackberries. The fruit should be picked at regular intervals, usually every other day. In some sections in very warm weather it will be necessary to pick every day, while in cooler weather three or four days may intervene between pickings. All ripe berries should be picked, because if any are left they will be too soft at the next picking to be shipped with the other berries. These overripe berries, as well as injured or bruised berries, will decay more rapidly than sound ones and may cause all the adjacent berries in the basket to decay.

YIELDS.

The yields of dewberry plantations will vary greatly with the different conditions under which they are grown. The results obtained by growers in North Carolina may give some indication of the size of the crop. Crops of 100 crates of 32 quarts each per acre are obtained year after year. Though the average yields may be somewhat smaller, good plantations favorably located should yield as much. Some growers average much more, but these men show exceptional ability or have exceptional conditions. Figure 12 shows part of a field of the Lucretia variety, now 12 years old, which has averaged more than 100 crates per acre per annum since coming into bearing.

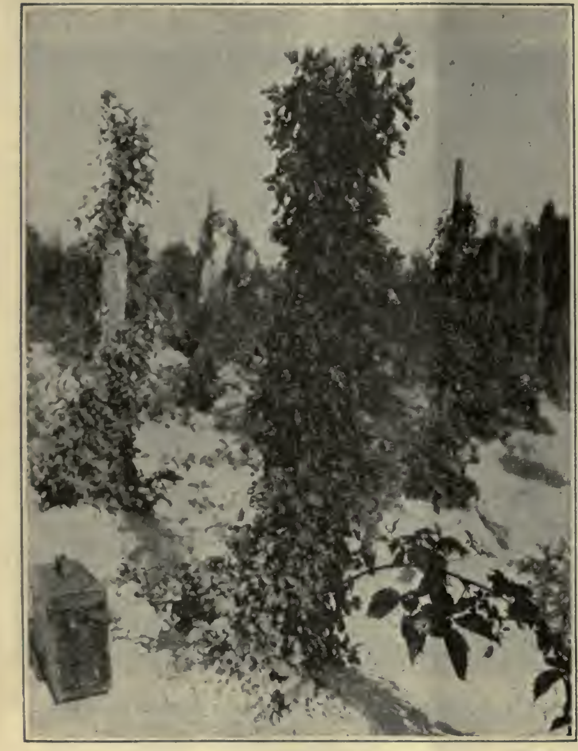

FIG. 12.—A Lucretia dewberry field in North Carolina, set in 1903, which has averaged more than 100 crates per acre since coming into bearing. (Photographed June 10.)

DISEASES AND INSECTS.

There are two serious diseases of the dewberry—anthracnose and double-blossom. Other diseases which may cause considerable trouble are the common leaf-spot, the orange rust, and the cane rust. Dewberry growers at present pay little attention to the last three diseases, though they undoubtedly cause considerable injury at times. The anthracnose and double-blossom are more serious and are controlled in southern sections by cutting off all the canes, both old and new, immediately after harvesting the crop; in fact, this cutting out of all the canes after the harvest is considered by southern growers as the most important operation in dewberry culture. In North Carolina the canes should be cut as close to the crown as possible and removed from the field. By thorough cultivation and the use of fertilizers vigorous new canes free from these two diseases will be secured by fall for bearing the next year's crop. In Texas the common practice is to mow the field after harvesting the crop and to burn the canes in the fields. Sometimes a bush scythe or sharp hoe is used for cutting the canes. Wherever the growing season is long enough to allow sufficient new growth to mature before winter to bear the next season's crop, either the North Carolina or Texas method should be used. Anthracnose is a serious disease in nearly all parts of the country. Double-blossom is common in New Jersey, Tennessee, and States south of them and as far west as Texas. This disease is controlled in sections where the canes are not cut off after picking by removing all buds which show infection in the spring.

Insects are not usually found to be serious on dewberries. Specific information in regard to both insects and diseases may be secured by writing to the nearest State agricultural experiment station or to the United States Department of Agriculture, Washington, D. C., and furnishing specimens of the affected parts.

PROPAGATION.

Plants may be secured from any reliable nursery at a reasonable price, and in starting a plantation this procedure is usually followed. Dewberry growers already having a plantation usually raise their own plants by covering the tips of the young canes with a few inches of soil late in the summer or early in the autumn. These tips will root freely, and new plants will be ready to dig late that fall or early the next spring. A rooted tip should be cut off 4 to 6 inches from the ground when desired for planting. Only the strongest plants should be set.

Sometimes the dewberry is propagated by means of root cuttings. When this method is used, pieces of the larger roots about 3 inches long are planted 2 or 3 inches deep. If the root cuttings are placed in moist but not wet sand in the late autumn they should have callused by spring. They should then be planted in the nursery row to grow for one year, after which they are ready to set in the field. This latter method is not often used, as rooted tips are secured so easily.

DURATION OF THE PLANTATION.

The duration of the plantation will doubtless depend on the section of the country in which the dewberries are grown, on the system of training used, and on the attention given it. In North Carolina plantations 15 years old are still productive. A few even older ones are still yielding well, but most of them have been planted too recently to make possible an accurate estimate of their probable life.

POLLINATION.

It has been found that when certain varieties of dewberries are planted by themselves no berries will be formed. The reason is that the flowers of such varieties do not have pollen that will fertilize their pistils. Some variety having flowers that open at the same time and bear an abundance of good pollen must be planted near them. Bees and other insects will then carry the pollen from the flowers of one variety to those of the other. The Gardenia, Lucretia, and Mayes varieties are usually self-fertile and may be planted by themselves without provision for cross-pollination. The Premo and some other less known varieties, such as the Chestnut, Manatee, and Rogers, are reported to be not entirely self-fertile, and should be planted with other varieties as pollinizers. The usual method is to plant two rows of one variety; then two rows of a second variety.

VARIETIES.

There are very few varieties of dewberries widely grown in the United States, the Lucretia being the leading variety in all except the Gulf Coast States. In Texas the Mayes is the leading variety, while in the other Gulf Coast States very few dewberries of any kind are raised. In California the Gardenia is raised to a considerable extent, while in North Carolina the Premo is grown slightly. The following notes will indicate the more important characteristics of the leading varieties.

Gardenia.—This variety has become very popular in California, but has not been extensively tested in the East. In California the canes are very productive, the berries large, long, of very good quality, and ripening about 10 days before the Lucretia.

Lucretia.—This is the best known and most widely grown dewberry. The canes are very vigorous and productive. In protected locations this variety is hardy in the Northern States. In Iowa, Minnesota, Colorado, and neighboring States it is usually protected in winter by covering with soil. The canes are susceptible to anthracnose and double-blossom. The berries are large, long, firm, of good quality, and are picked for shipping as soon as they turn black, but they do not become very sweet unless they are left on the plants a day or two longer. They ripen about June 1 in the North Carolina section, and are later than the Gardenia, Mayes, or Premo.

Mayes (synonym, *Austin Mayes*).—This variety originated in Texas and is the leading one in that State. It has been grown to a slight extent in many other States, but although considered more productive and earlier than the Lucretia it is too soft to ship far. The canes are vigorous, productive, and subject to double-blossom and anthracnose. The berries are very large, not as long as the Lucretia, and have large drupelets. (See fig. 1.) Although soft for shipping, they are of excellent quality. The variety ripens at least a week before the Lucretia and slightly earlier than the Premo.

Premo.—The Premo is grown to some extent in the dewberry section of North Carolina and in other parts of the eastern United States. It ripens its fruit in North Carolina nearly a week earlier than the Lucretia, and for this reason is considered desirable by many growers. The plants resemble the Lucretia very closely, but are not as productive. The flowers are imperfect, and plants of one of the other varieties must be set near to pollinate this variety. The berries average slightly smaller than the Lucretia, but are as firm and as good in quality.

HYBRIDS AND RELATED FORMS.

Several other varieties of dewberries are grown to a slight extent, some of which give promise of being valuable in certain limited sections. There are also several blackberries and blackberry-dewberry hybrids, which are sometimes, or usually, trained like the dewberries. Thus, the McDonald, a blackberry-dewberry hybrid, listed with blackberries in a previous publication,[1] is trained in the same manner as the dewberries in Texas. Farther north it is commonly trained in a manner similar to that of the ordinary blackberry. It ripens nearly 10 days before the Lucretia and may be planted in dewberry sections with the Lucretia as a pollinizer for it. The Mammoth, another blackberry-dewberry hybrid listed in Farmers' Bulletin 643 and grown on the Pacific coast, trails on the ground like the dewberries. It is, however, somewhat more vigorous and should have a pollinizer. On the Pacific coast the Evergreen blackberry and in New Jersey the Diamond (*Black Diamond*, *Star*, *Wonder*, *Ewing Wonder*, *Atlantic Dewberry*) blackberry, supposed to be a seedling of the Evergreen, are trained in a manner similar to that used for dewberries. In New Jersey the Diamond is trained to stakes, as illustrated in figure 10. The Evergreen is trained to a wire trellis, as illustrated in Farmers' Bulletin 643.

SUMMARY.

The dewberry, although closely related to the blackberry, is distinguished from it in having trailing canes that root at the tip and in having small flower clusters, while the canes of most blackberries are erect, do not root at the tip, and the flower clusters are large. The dewberry is grown for its fruit, which ripens earlier than that of the blackberry.

At present the dewberry is raised more widely in North Carolina and New Jersey than in other States, but it is adapted to nearly all parts of the country. Although suited to many types of soils it is grown most extensively on coarse sandy loams. Its deep rooting system enables it to secure moisture from such soils better than many other crops.

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[1] Darrow, G. M. Blackberry culture. U. S. Dept. Agr., Farmers' Bul. 643, 13 p., 8 figs. 1915.

The plants are usually set in early spring, either 5 feet distant each way or 3 feet apart in rows 4 to 6 feet apart, depending on whether the hill system of culture or the solid-row system is to be used. Until the canes begin to interfere, thorough cultivation is given the first season.

The following spring, just before the buds start, is the usual time to train the canes. In North Carolina and in some other States where the hill system is used, stakes about 2 inches square are set by each plant and project about 5½ feet above the ground. The canes are then gathered together, wound in a spiral about the stake, and tied with coarse string. After the crop has been harvested, both old and new canes are cut off at the surface of the ground and removed from the field. This cutting out of the old canes removes all the diseases on them, and the new canes, which later grow up, are usually free from disease.

Where the solid-row system of culture is employed many methods of training are used. In many places a post about 3 feet high is set between every two plants. The canes from each of the two plants are brought to the top of this post and tied to it, the projecting ends of the canes being then cut off.

In regions where posts are expensive a wire trellis is often used. Posts are set along the row from 20 to 40 feet apart, and a wire about 3½ feet above the ground is stretched along them. The canes of each plant are gathered together and tied to the wire.

In southern regions, where the seasons are long enough to allow sufficient new growth to appear, all the canes, both old and new, are cut off after the fruit has been picked. In northern regions, where sufficient new growth can not be secured, the old canes only are removed at this time.

In some places where the solid-row system is used the canes are allowed to run on the ground or are thrown over a low wire about a foot above the ground. This makes picking more difficult, but saves expense in training. In Texas and some other Southern States where this method is used the canes are mowed off at the surface of the ground and burned. This cleans the field of disease, and the new growth of canes is much healthier.

The Lucretia is the variety principally grown and is generally the most desirable. The Mayes is the leading variety in Texas, but its fruit is softer than that of the Lucretia. The Premo, which closely resembles the Lucretia, ripens earlier but is not generally as productive. The Gardenia is grown to some extent in California, but has not yet proved to be adapted to the eastern United States.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 729 JULY 19, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

CORN CULTURE IN THE SOUTHEASTERN STATES.

By C. H. KYLE, *Assistant Physiologist, Office of Corn Investigations.*

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INTRODUCTION.

The area involved in the discussion of this subject includes North Carolina, South Carolina, Georgia, Florida, and Alabama. The recommendations and suggestions made apply mostly to the cotton-growing portion of those States.

PREPARING LAND FOR CORN.

DRAINAGE.[1]

Poor drainage is indicated in many fields by the irregular patches in which little or no corn grows. Even if actual drowning does not occur in these places, the growth is so weakened and retarded that worms commonly destroy the stand. Besides the regular means of draining, applications of coarse stable manure are recommended.

CONSERVATION OF RAINFALL.

Although the average annual rainfall ranges from 46 to more than 60 inches and is comparatively well distributed, the most common need of the corn crop is more moisture at some time in its development. Preparation of the land so that it will retain larger quantities of water for longer periods is therefore very important and will give greater returns on the investment than any other one part of the crop's culture. The capacity of a soil for moisture will depend much upon the depth to which the land is plowed and the quantity of humus (decaying vegetable matter) incorporated with it.

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[1] See Smith, A. G., Tile drainage on the farm, U. S. Dept. Agr., Farmers' Bul. 524, 27 p., 15 fig., 1913.

PLOWING.

Land should be broken from 8 to 10 inches deep. If the land is in a poor state of cultivation this is best accomplished by turning only that part which previously has been broken and loosening the rest of the depth with a subsoil plow. The subsoil plow will be most efficient when it is made to follow in the furrow of the turnplow. In following seasons the land may be turned deeper, the increased depth varying with the quantity of vegetable matter incorporated during the last preparation. When a soil of the required depth has been established, the turnplow may be run from 6 to 8 inches deep at each preparation and the subsoil plow only as often as seems necessary to prevent the formation of a compact layer just below the depth of the turnplow.

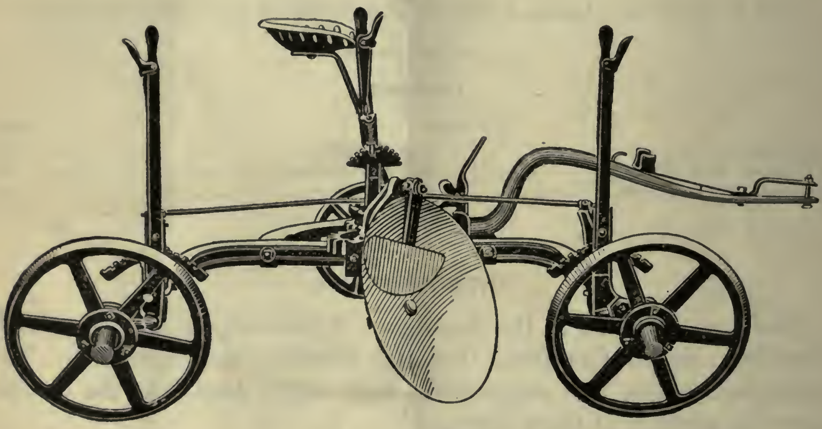

FIG. 1.—A reversible disk plow.

In order that the plows may accomplish the greatest amount of pulverizing, the work should be done when samples of the soil crumble most readily in the hand. The period when the best work may be done frequently passes before all of the land can be prepared. If the surface of the land is thoroughly pulverized with a disk harrow or other implement as soon as it is dry, the period for efficient work will be greatly extended.

Figure 1 illustrates a disk plow that reverses, so that the furrows may all be turned in one direction. It is especially valuable on steep hillsides and where it is necessary to avoid open furrows.

Figure 2 illustrates a type of walking turnplow that is adapted to the mixed sand and clay soils of the South Atlantic States.

Well-adapted harrows and other types of tools for pulverizing and smoothing the soil after it has been broken are now common in every community. Frequently, however, the land is not worked until its surface has dried. The closer the breaking plows are followed by the surface tools, the less time and labor it will require to do the work.

HUMUS.

Nothing will do more to economize the labor of tilling the land and to prolong the good effects of tillage than the presence of an ample quantity of humus in the soil. All land intended for the profitable cultivation of corn should be stocked with such material as soon as possible. The best preparatory crops for corn are the legumes, some of which are cowpeas, velvet beans, vetch, the clovers, and beggarweeds. These crops may be made to supply much vegetable matter and, in addition, a part or all of the necessary nitrogen.

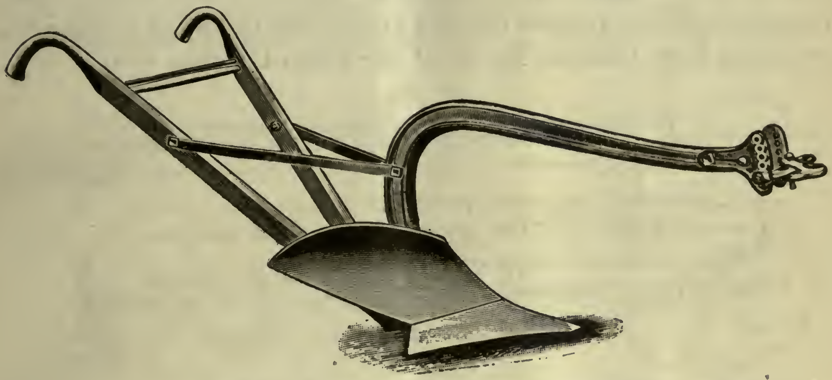

FIG. 2.—A good type of walking turnplow.

Manure produced in connection with the raising of live stock always has been associated with the highest type of agriculture. An inconsiderable amount of it is at present produced on most farms, because there are so few animals. Its great value, however, in connection with the production of corn and other crops should command careful consideration.[1]

COMMERCIAL FERTILIZERS.[2]

Commercial fertilizers should be used to supply such elements of plant food as can not be supplied by the soil and by cropping systems in sufficient quantities for the greatest profit. Usually it is desirable to supply nitrogen, phosphoric acid, and potash in some one or more of their various forms. The proportions of these fertilizer constituents that it is necessary to use vary with the soil and the general cropping system.

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[1] See Beal, W. J., Barnyard manure, U. S. Dept. Agr., Farmers' Bul. 192, 32 p., 4 fig., 1904.

[2] For a general discussion of the whole subject of commercial fertilizers, see the following: Voorhees, E. B., Commercial fertilizers: Composition and use, U. S. Dept. Agr., Farmers' Bul. 44, 24 p., 1896; Beavers, J. C., Farm practice in the use of commercial fertilizers in the South Atlantic States, U. S. Dept. Agr., Farmers' Bul. 398, 24 p., 2 fig., 1910.

Extensive tests over a long period of years are urgently needed as a guide in choosing a fertilizer for each of the many different conditions in the section. At present some of the most satisfactory data available are those of the North Carolina Agricultural Experiment Station. These cover a period of 10 or 12 years in the Coastal Plain and Piedmont sections of North Carolina. As a result of these tests, the station mentioned recommends the following fertilizer formulas and practices for the average unimproved sandy and sandy-loam soils in the Coastal Plain section and for the clay and clay-loam soils in fair condition in the Piedmont section of that State. These recommendations, printed in small type in the following paragraphs, are taken from Circular No. 18 of the North Carolina station.

Fertilizer formulas for the Coastal Plain section.

No. 1.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	600
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	1, 200
Kainit, 12 per cent potash	200
	2, 000

This mixture will contain: Available phosphoric acid, 5.5 per cent; potash, 2.3 per cent; nitrogen, 3.7 per cent (equal to ammonia, 4.5 per cent).

No. 2.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	765
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	650
Nitrate of soda, 15 per cent nitrogen	265
Kainit, 12 per cent potash	320
	2, 000

In this formula one-half of the nitrogen is supplied by nitrate of soda and the other one-half by cottonseed meal. This mixture will contain: Available phosphoric acid, 7.0 per cent; potash, 2.5 per cent; nitrogen, 4.0 per cent (equal to ammonia, 4.9 per cent).

No. 3.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	680
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	935
Nitrate of soda, 15 per cent nitrogen	125
Kainit, 12 per cent potash	260
	2,000

In this formula one-fourth of the nitrogen is supplied by nitrate of soda and the other three-fourths by cottonseed meal. This mixture will contain: Available phosphoric acid, 6.8 per cent; potash, 2.4 per cent; nitrogen, 3.8 per cent (equal to ammonia, 4.6 per cent).

No. 4.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	650
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	1,300
Muriate of potash, 50 per cent potash	50
	2,000

This mixture will contain: Available phosphoric acid, 7.0 per cent; potash, 2.4 per cent; nitrogen, 4.0 per cent (equal to ammonia, 4.9 per cent).

No. 5.

	Pounds.
Acid phosphate, 14 per cent phosphoric acid	1,170
Dried blood, 13 per cent nitrogen	715
Muriate of potash, 50 per cent potash	115
	2,000

This mixture is quite concentrated on account of the high-grade phosphatic and potassic materials used and will contain: Available phosphoric acid, 8.2 per cent; potash, 2.9 per cent; nitrogen, 4.6 per cent (equal to ammonia, 5.6 per cent).

Fertilizer formulas for the Piedmont section.

No. 1.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	750
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	1,250
	2,000

This mixture will contain: Available phosphoric acid, 7.8 per cent; potash, 1.1 per cent; nitrogen, 3.9 per cent (equal to ammonia, 4.7 per cent).

No. 2.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	930
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	680
Nitrate of soda, 15 per cent nitrogen	280
Kainit, 12 per cent potash	110
	2,000

In this formula one-half of the nitrogen is supplied by nitrate of soda and the other one-half by cottonseed meal. This mixture will contain: Available phosphoric acid, 8.4 per cent; potash, 1.3 per cent; nitrogen, 4.2 per cent (equal to ammonia, 5.1 per cent).

No. 3.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	835
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	980
Nitrate of soda, 15 per cent nitrogen	135
Kainit, 12 per cent potash	50
	2,000

In this formula one-fourth of the nitrogen is supplied by nitrate of soda and the other three-fourths by cottonseed meal. This mixture will contain: Available phosphoric acid, 8.1 per cent; potash, 1.2 per cent; nitrogen, 4.0 per cent (equal to ammonia, 4.9 per cent).

No. 4.

	Pounds.
Acid phosphate, 16 per cent phosphoric acid	1,200
Dried blood, 13 per cent nitrogen	740
Muriate of potash, 50 per cent potash	60
	2,000

This mixture is a concentrated one on account of high-grade nitrogenous and potassic materials being used, and will contain: Available phosphoric acid, 9.6 per cent; potash, 1.5 per cent; nitrogen, 4.8 per cent (equal to ammonia, 5.8 per cent).

NITRATE OF SODA.

This material is quick acting because of its easy solubility in water. For this reason, when used in a considerable quantity in fertilizers at time of planting, especially on light sandy land, there is considerable danger of its being leached beyond the reach of the roots of the plants before they can use it. On clay lands and loams having good subsoils to them, this danger does not exist, certainly not to the extent that it does on light soils. A small amount of nitrate of soda in the mixture will give the crop a quick start and make its cultivation easier and more economical. Formula No. 3 has been arranged with this idea in view, and in No. 2 one-half the nitrogen comes from nitrate of soda. On light lands it would likely be better to omit the nitrate from the mixture and apply it as a top-dressing between the 10th and last of June on early corn. Nitrate of soda may take the place of a portion of the other nitrogen-furnishing materials in any of the formulas, 1 pound of nitrate being equal in its content of nitrogen to 2.4 pounds of cottonseed meal, 1.8 pounds of fish scrap, or 1.2 pounds of dried blood. Nitrate of soda is frequently used as a top-dressing for corn and is a very valuable material for use in this way. A good application is 50 to 75 pounds per acre, distributed along the side of the row or dropped beside the plants and 3 or 4 inches from them, or else where there is a ridge in the center it may be distributed on this, and when it is thrown out the nitrate will be thrown to the two sides of the row.

APPLICATION OF FERTILIZERS TO CORN.

On clay lands and loams having good subsoil the fertilizer should be applied in the drill, at or just before planting, at the rate of 200 to 400 pounds per acre. On light sandy lands it is best to use 50 to 100 pounds in the drill at time of planting, to give the crop a good start, and the balance of the fertilizer as a side dressing when the corn has begun to grow well.

No part of the method of culture requires more intelligence on the part of the grower than the proper supply of commercial fertilizer to corn. For the man who is able and willing to meet the conditions in each case as they arise, the following suggestions are offered: Apply all the fertilizer that supplies nothing but phosphorus and potash on the line of the row at or before the time of planting. It should be mixed with the soil as thoroughly and widely as is practicable. If experience has shown that the early growth is liable to be so slow and weak that there is difficulty in getting a stand, from 25 to 30 pounds of nitrate of soda should be distributed with the seed. The remaining portion of the necessary nitrogen should be supplied from time to time while cultivating the corn. The amount of nitrogen supplied in this way should be governed somewhat by the rate at which the corn is growing. As a general rule, the early applications should be comparatively light and the late applications comparatively heavy, the idea being to avoid an excessively rapid and tender growth at any time and thus avoid some of the damage that is always likely to result from a drought.

Nitrate of soda is the best form in which to supply nitrogen by this system.

Fertilizer attachments for cultivators are the best devices for distributing nitrate of soda.

FERTILIZERS FOR CORN FOLLOWING PEAS AND OTHER LEGUMES.

The best and most profitable yields of corn in our experimental work were where the corn followed soy beans, bur clover, cowpeas, crimson clover, and other leguminous crops. These crops, with acid phosphate and kainit or some other potash salt, are the best previous treatment and fertilization for corn. Where light crops of peas have been grown in corn or cut from the land and the stubble left, it would be safest to add some nitrogenous material in the fertilizer mixture. In cases of this kind it is suggested that the nitrogen-furnishing material in any of the preceding formulas be reduced one-half. Where corn is to follow good crops of cowpeas, soy beans, bur and crimson clovers, especially where the entire crop has been left on the soil, no further application of nitrogen need be made, but it is advised that 200 to 300 pounds per acre of the following mixture, in the drill, be used just before planting:

	Pounds.
Acid phosphate, 16 per cent	200
Kainit, 12 per cent	100

RESULTS IN SOUTH CAROLINA.

The South Carolina Agricultural Experiment Station reports in Bulletin No. 178 of that station that at Summerville, S. C. (in the Coastal Plain), a formula approximating 10 per cent phosphoric acid, 4 per cent potash, and 3.3 per cent nitrogen (equal to 4 per cent ammonia) is the best for those conditions. This bulletin also indicates that acid phosphate is the most profitable source of phosphorus under the conditions specified.

PLANTING.

TIME OF PLANTING.

There is considerable latitude allowed for planting, because of the long seasons. The question is frequently raised whether one should plant early (from the middle of March to the first week in April) or late (May 1 to July 1).

In considering the question, the budworm or southern corn rootworm (*Diabrotica duodecim-punctata* Oliv.) is probably the most influential factor.

Over the greater part of the area considered, the worms appear most abundantly in April, though this period varies with the latitude and the weather. Many farmers try to plant either before or after this main attack. It has been shown,[1] however, that the adult insect is usually on hand to lay eggs even before corn can be planted, and it is therefore likely that if the soil conditions are favorable to the insect the early-planted corn will have but little success in avoiding the worms. On the other hand, corn planted from the first to the 10th of May (depending on the latitude) will suffer practically no damage from these worms.

It has been observed that a cold, wet soil favors budworms. It is probable that artificial drainage and coarse farm manure will do much to dispose of this trouble and thereby render the grower more independent as to the time of planting.

Much of the land in these States has fairly good drainage and the soil early becomes warm and well aerated. On this land the budworms usually do little or no damage at any time, and the farmer is thus freed from the limitations just mentioned. On such land the heaviest yields of corn are usually obtained by planting as soon as a permanent stand can be secured.

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[1] Turner, W. F. Bud-worms in corn. Ala. Agr. Exp. Sta. Cir. 8, 7 p., 1 fig., 1911.

MANNER OF PLANTING.

On warm well-drained land it has become very popular to plant corn in the water furrows left by plowing the land into beds, the width being that desired between the rows.

Planting in furrows has three special advantages:

(1) The growth of corn planted in furrows is for the most part easily controlled.

(2) The cultivation of furrow-planted corn at the time when root injury is usually most serious consists largely of working down the soil of the bed about the corn. Injury to the roots by the cultivators is therefore hardly possible.

(3) Corn planted in furrows is much more easily kept clean in the row than that planted on the level, because in bedding many of the weed seeds are thrown out of the furrows and as the corn grows the earth is filled in about the plants and the weeds and grass that start there are easily covered.

The preparation of the furrows is usually made a special consideration after the land has been broken flat. The land is first bedded with a plow, a disk harrow, or a disk cultivator. The beds are made wide enough so that the furrows between them will be properly spaced for the rows. Another way that requires less labor and that protects the young corn from the wash of the beds is to open the furrows for planting with a middle breaker. The beds are then completed by throwing the soil away from the rows during the early cultivation. When the subsoil is naturally hard and the land is broken less than 8 inches deep, the bottom of these furrows is frequently loosened as deep as is practicable. The ordinary 1-horse planter is well adapted to planting in these furrows and on beds.

On land that has been properly prepared, much of the above-described labor may be eliminated, time saved, and the work better done by using a lister. These machines open the furrow and plant the corn below the level at the same time. They insure a uniform depth for the seed and make it possible to plant the seed shallow and at the same time in moist soil. Figures 3 and 4 show good types of the lister. These two forms are intended for compact land, but will give satisfaction in freshly plowed land if it contains considerable sand. Figure 5 shows a field that has been planted with one of these machines. The rows shown in this illustration were 3½ feet wide, but any other width may be used.

When the lister is used and it is desirable to apply commercial fertilizer before planting, a fertilizer drill should precede the planter on the line of the row and distribute the fertilizer slightly above the depth the lister is run. By so doing, the lister will spread the fertilizer to at least the width of its cutting edge and to both sides of the seed, and the danger of injuring the sprouting corn by contact with the fertilizer will be removed.

On poorly drained clay land, corn frequently will be drowned out if planted in furrows, especially if these are deep. Any clay land that has had shallow preparation will tend toward the same trouble. Under these conditions the furrows must be shallow or the planting made on the level of the land.

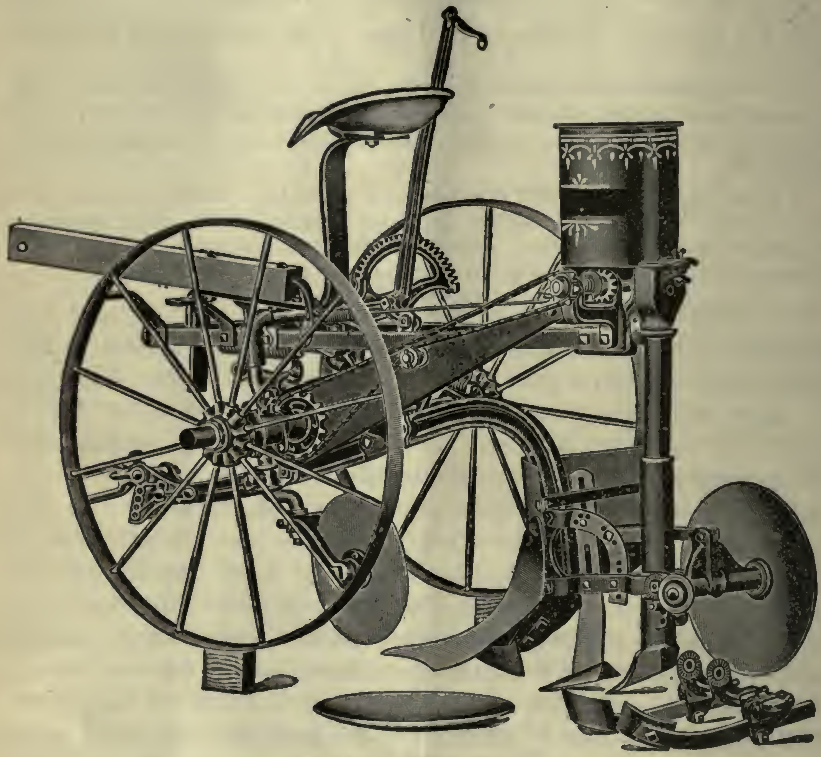

Fig. 3.—A riding lister.

In some cases on low coast land, corn must be planted in beds, so that after rains the water will be permitted to escape before the crop is damaged. It is then advisable to make the beds wide enough for two or more rows.

In planting, the seed should be covered just deep enough to have sufficient moisture in which to germinate promptly. A depth greater than this tends to weaken the plants and thus lessens their chances for success. On well-prepared clay land, and especially where the planting is in a furrow, a half inch of cover may be sufficient. When the soil is dry, cloddy, or otherwise poorly conditioned for planting it is necessary to plant deeper.

DISTRIBUTION OF PLANTS.

The best distribution of plants over the land is obtained by making the distances between single plants in the row and the distances between rows the same. With such an equal distribution, the least possible loss from competition is experienced. However, in order that sufficient plants be grown upon an acre to utilize most completely the resources of the soil and climate and at the same time permit intertillage and other desirable practices, it is usually necessary to sacrifice some of the advantages to be gained by even distribution for those to be gained by other desirable cultural practices. These cultural methods frequently may be altered so as to reduce this loss, and the greatest saving in this connection is by means of implements specially adapted to this work. Where general-purpose implements are used, distances between rows of as much as 5 or 6 feet are often considered necessary. By preparing the land thoroughly and then using highly specialized machinery for planting and cultivating the corn, the rows need be no more than 3½ feet apart and the distances between plants in the rows can be increased accordingly.

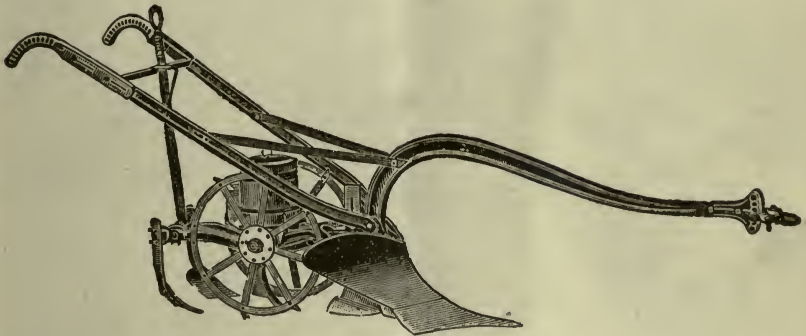

FIG. 4.—A walking lister.

NUMBER OF PLANTS PER ACRE.

The number of plants per acre required for the best results will depend more or less upon the natural fertility of the land, the quantity of fertilizer used, the method of culture practiced, the time of planting, the evenness of the distribution of plants, whether other crops are grown with the corn, the variety, and the season.

The season is, of course, the most important factor influencing the stand required and, as its character can not be foretold, it is evident that specific advice in this connection can not be given.

In practice, corn is commonly planted in stands ranging from 3,630 to 7,260 plants per acre, or 6 to 12 square feet per plant. Most stands of corn have been planted with an allowance of 8 to 12 square feet per plant.

Probably the most important factor involved in the proper adjustment of the stand to the ever-varying environment lies within the variety itself. Plants of all varieties of corn tend to adjust themselves to their growing conditions by increasing or decreasing the stalk yields. As a general rule, the varieties capable of the widest range of adjustment are those that have a strong tendency to produce more than one ear per stalk.

SECURING A STAND.

One of the most deplorable losses due to defective stand is from the blank spaces seen to a greater or less extent in practically every field. The ability of the plants to utilize extra space rapidly diminishes as the distance increases, and the practical limit probably does not exceed 5 or 6 feet. Beyond this distance the loss so far as the corn crop is concerned is complete.

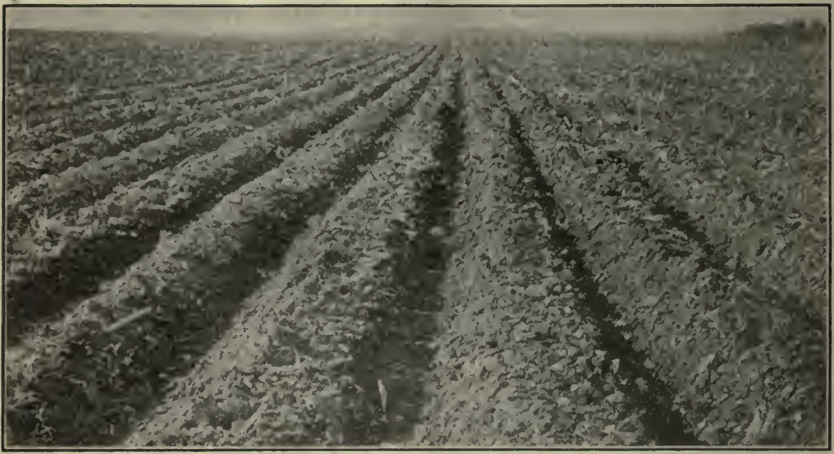

FIG. 5.—A field after planting with a lister.

Good seed of a uniform size and shape is an important factor in securing a stand. Special bulletins upon seed corn can be obtained without cost from the United States Department of Agriculture.[1]

Burrowing animals and birds frequently do serious damage to the stand by eating the seed or by pulling up the very young plants. Odorous substances have been tried in various ways to prevent such attacks. The substance that is most favorably considered for this purpose at present is coal tar, because it seems successful as a repellent, it will not injure the seed, costs very little, and may be dried so as to plant freely in a machine. It is recommended[1] that the seed be wet with warm water before adding the tar. A teaspoonful of the tar will be sufficient for a peck of corn. The mass must be thoroughly mixed and then dried before planting.

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[1] Hartley, C. P., and Webber, H. J. The production of good seed corn; with an appendix on selection and care of seed corn. U. S. Dept. Agr., Farmers' Bul. 229, 23 p., 10 fig., 1905.

Duvel, J. W. T. The germination of seed corn. U. S. Dept. Agr., Farmers' Bul. 253, 16 p., 4 fig., 1906.

Hartley, C. P Seed corn. U. S. Dept. Agr., Farmers' Bul. 415, 12 p., 3 fig., 1910.

Blank spaces are commonly due to clods and trash that prevent the planter from properly packing the seed in fine moist earth. This trouble can be practically eliminated by using a lister.

In wet, cold land the seed sometimes is covered with too much soil. On such land the seed should be planted just deep enough to have it in contact with moist soil.

Large quantities of acid fertilizer applied in the row at or about the time the corn is planted may kill sprouting seed or cause the plants to be weak. The trouble may be overcome by making the application ten days or two weeks earlier.

In cold weather or on low, flat, or otherwise poorly drained land the seed may germinate badly, and the plants that start are slow in growing and weak. Worms, grass, and weeds are likely to destroy such corn if it is not assisted. From 25 to 30 pounds of nitrate of soda per acre, applied with the corn drill at the time the corn is planted, will quickly force the young plants past the period of greatest loss and thus greatly increase the chances of securing a stand.

Whenever it is at all difficult to get the desired stand, extra seed should be planted to offset the loss. Thinning will usually result in greater economy than leaving a defective stand or replanting.

CULTIVATION.

Cultivation may be for one or more reasons. Some of these are as follows:

(1) By cultivating the soil away from the row while the corn is young it may retard the rate of growth and thus under certain conditions will favor the success of the crop.

(2) By cultivating the beds between rows of furrow-planted corn to a level, the corn may be suddenly put within immediate reach of the soil's greatest fertility. This done at the right time will favor the greatest production of grain.

(3) Weed destruction is one of the most important functions of cultivation. Weeds are most easily destroyed as they are coming through the surface of the ground. Thorough surface cultivation will suffice at this time. When weeds and grass are well started, not only is there a rapid exhaustion of the moisture and plant food in the soil, but the cultivation necessary to remove them will often seriously damage the crop by covering the corn and, when planted on or above the level, breaking its roots.

(4) When it is desirable to supply commercial fertilizer to the growing crop it is sometimes necessary to mix the application with the soil. For this, cultivation may be required, and the most practicable way is to combine this with one of the usual cultivations.

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[1] See Scheffer, T. H., Treating seed corn to protect it from burrowing animals, Kans. Agr. Exp. Sta. Cir. 1, 4 p., 1909.

(5) Shallow early cultivation by maintaining a loose soil mulch will conserve soil moisture. Deep early cultivation by permitting more air to enter will dry and warm the soil about the corn. After corn is from 2 to 3 feet high (varying with the width between rows), its roots so fill the soil that it is believed that practically no moisture on its way to the surface can escape them. For this reason, late cultivation for the sole object of conserving moisture is now considered impracticable.

EARLY CULTIVATION.

When corn is planted in furrows, the early cultivation need consist of little more than harrowing the bottom of the furrows on both sides of the row. If the furrows were made with a lister, a harrow of the type shown in figure 6 is the best. The uniform furrows guide the different sections of the harrow. The mules or horses walk upon the beds and soon require but little attention. One man is thus able to cultivate as many as five rows at a time. If the furrows were made by other means, as previously described, the early cultivation may be done with cultivators of the type shown in figure 7. In this case, the clevis will have to be so adjusted that the horse or mule can walk just to one side of the row, while the cultivator works both sides of it. It is also necessary to remove at least one of the teeth on each side. The early cultivations of furrow-planted corn should leave the furrows entirely open. If it is desirable to leave them open very late, the beds may require cultivation in order to prevent the growth of weeds, and this can be done with a disk cultivator set to throw the soil away from the rows.

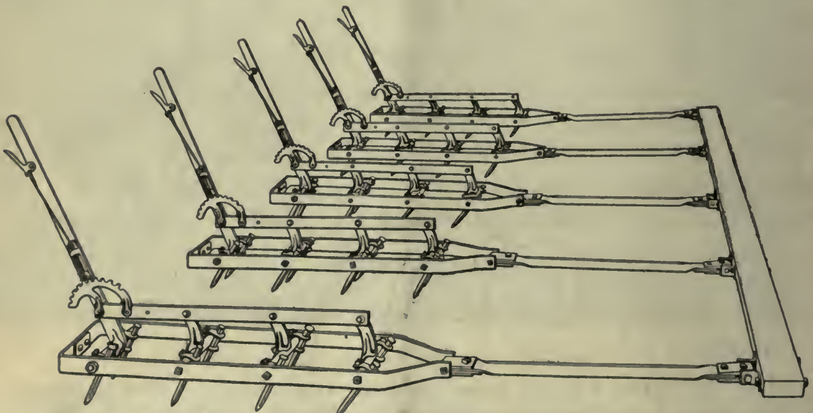

FIG. 6.—A harrow for cultivating corn in lister furrows.

LATE CULTIVATION.

The late cultivation of furrow-planted corn consists in filling the furrows with soil from the beds. For this, the disk cultivators are among the best. This leveling process may be done in one or more cultivations, as seems desirable. It may be delayed until it is apparent that the corn is about to start tasseling, if the weeds do not become a menace. As the roots at this time will not have gone upward into the beds that have been formed between the rows, a loose, deep, rich mulch may thus be thrown about the stalks without the slightest damage, leaving the crop well prepared to pass its most critical period.

In order to destroy weeds, other cultivations may follow the leveling of the land. This should be done, however, with surface-working cultivators, so that it will not be possible to cultivate deep.

A smoothing harrow with teeth pointing backward, or, where the soil is very fine and mellow, a horse weeder with long spring teeth, may be used until the corn is 6 inches high for the cultivation of corn planted on or above the level of the land. After this, any cultivator that will not exceed a depth of 2 inches may be used. When the corn is drilled, the weeds in the row will have to be removed with a hand hoe. In some cases the corn may be planted in hills, so that it can be cultivated both ways. Much hoeing may thus be eliminated.

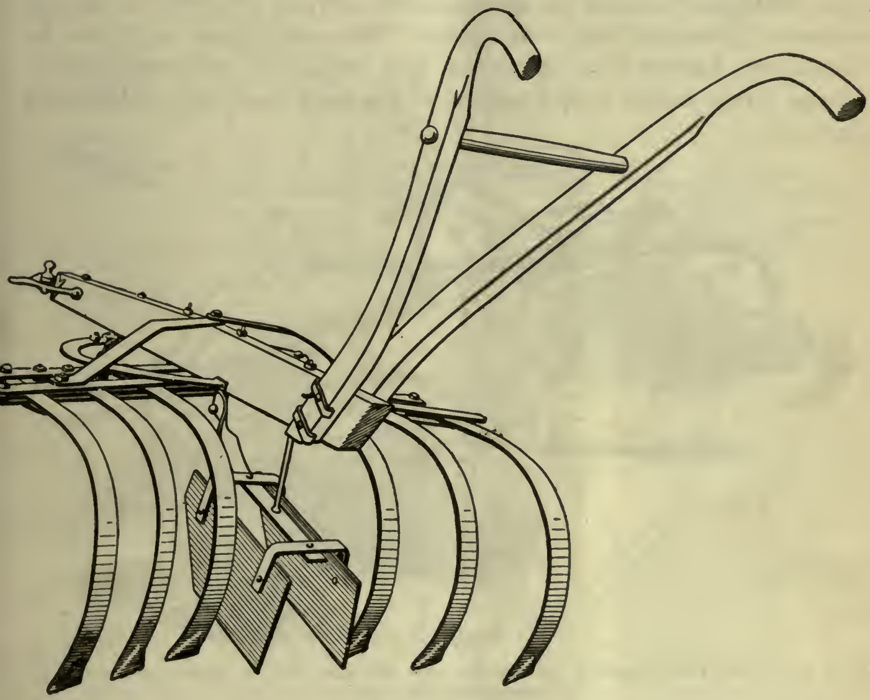

FIG. 7.—A cultivator that can be used to cultivate corn in an ordinary water furrow.

Figure 8 illustrates a type of cultivator that is especially adapted to the cultivation of corn in furrows made by a lister. This one cultivates two rows at a time, but 1-row cultivators of this type are made.

These machines are so constructed that they are guided by the furrow, and when properly adjusted anyone who is able to drive the team can cultivate two rows at a time in the best manner possible. In using these cultivators, the rows are usually gone over once or twice with the disks set to throw the soil from the corn. During the third cultivation the disks are set to throw the soil to the corn, and at this time the furrows are nearly filled. The fourth and last cultivation is usually done with a high-arched cultivator of one of the types shown in figures 9 and 10. In each of these illustrations the cultivators are equipped with scrapers that smooth the land behind the disks or knives. For the fourth cultivation, the gangs on the disk cultivator should be set to throw toward the row, or in the opposite direction from that shown. This cultivation may also be done with harrows or any other tool that will cultivate shallow (from 1 to 2 inches deep) and leave the land free from ridges and furrows.

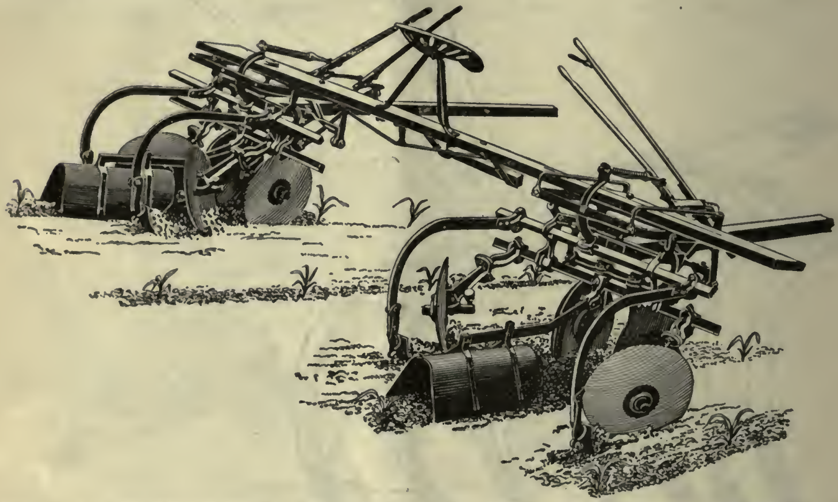

FIG. 8.—A cultivator specially constructed for the first two or three cultivations of lister-planted corn.

Figure 11 shows cultivators equipped with fertilizer attachments, so that a side application may be made at the time the cultivation is done. Fertilizer-distributing attachments can be made for most kinds of corn cultivators, and manufacturers will produce them when there is a sufficient demand. In a large portion of the section covered by this bulletin such attachments, conveniently and substantially made for the types of cultivators illustrated in figures 8, 9, and 10, should not only economize the time and labor necessary for distributing the fertilizer, but by being able to supply the fertilizer at each of the cultivations a farmer would not need to apply a large quantity at any one time, and the danger of overstimulating growth would be practically eliminated.

SUMMARY.

The recommendations and suggestions made in this bulletin apply mostly to the cotton-growing sections of North Carolina, South Carolina, Georgia, Florida, and Alabama.

Drainage and coarse stable manure should be used to prevent the irregular patches in the field in which little or no corn grows.

More of the rainfall is retained when the land is broken from 8 to 10 inches deep and vegetable matter is supplied.

Humus economizes the labor of tilling the land and prolongs the good effects of cultivation.

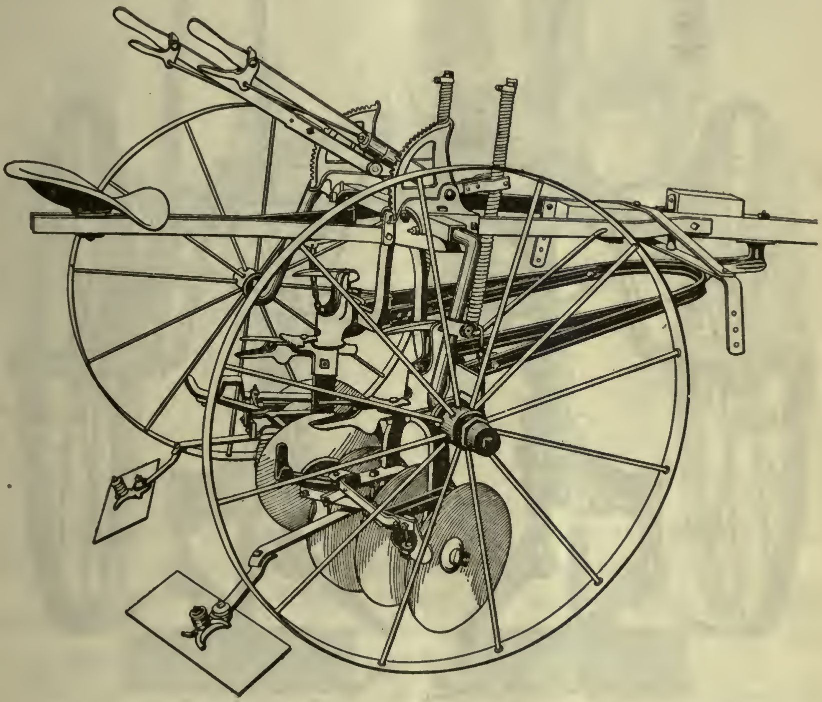

FIG. 9.—A disk cultivator equipped and adjusted so the land will be left level.

Crops like cowpeas, velvet beans, vetch, the clovers, and beggarweed may be made to supply both humus and nitrogen.

Commercial fertilizers should be used to supply such elements of plant food as can not be supplied by the soil and by cropping systems in sufficient quantity for the greatest profit.

The fertilizer formulas published by the North Carolina and South Carolina agricultural experiment stations are recommended.

Budworms may make it necessary to plant after the first of May, but drainage and coarse stable manure may relieve this condition.

The heaviest yields of corn are usually obtained by planting as soon as a permanent stand can be secured.

On warm well-drained land corn in furrows has the advantage over that planted by other methods, because its growth may be better controlled, serious injury to the roots in cultivating is avoided, and weeds and grass are more easily combated. Methods of preparing furrows and planting in them are described and special attention is called to the desirability of using the lister.

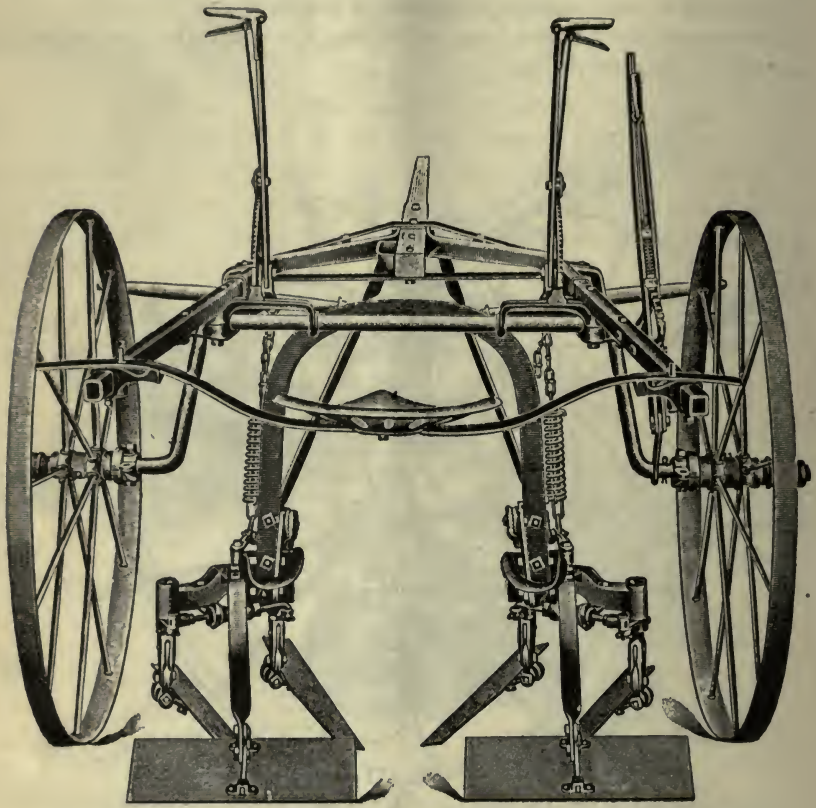

FIG. 10.—A cultivator specially adapted for level shallow cultivation.

The seed should be covered just deep enough to have sufficient moisture in which to germinate promptly.

A more uniform distribution of plants, resulting from a decrease in the distance between rows and an increase in the distance between plants in the rows, is often desirable, and this may be accomplished by the use of special machinery.

Most stands of corn have been planted so as to allow from 8 to 12 square feet per plant. Plants of all corn varieties tend to adjust themselves to their growing conditions by increasing or decreasing the stalk yields, but as a general rule the varieties capable of the widest range of adjustment are those that have a strong tendency to produce more than one ear per stalk.

Burrowing animals and birds may be prevented from eating the seed and pulling up the young plants by using coal tar.

Where present methods fail to give a stand in cloddy or trashy land, a lister will usually succeed.

From 25 to 30 pounds of nitrate of soda applied with the corn drill at the time of planting will quickly force the young plants past the period of greatest loss and thus, where the conditions are trying, will greatly increase the chances of securing a stand.

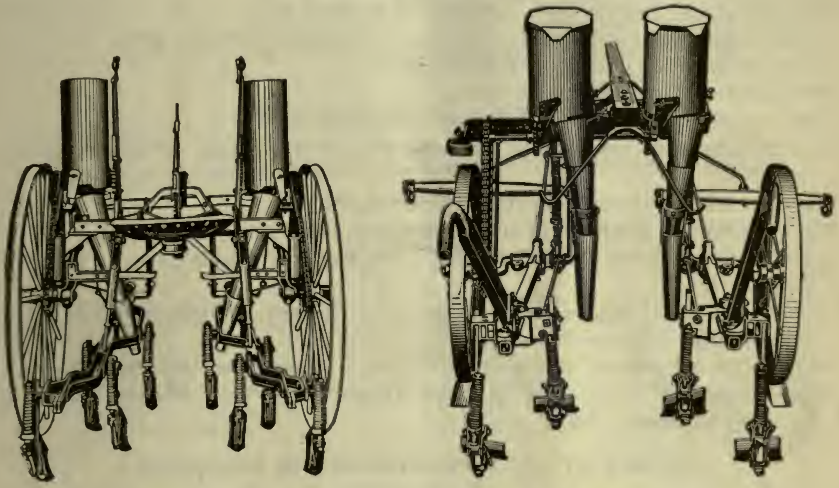

FIG. 11.—Riding and walking cultivators equipped with fertilizer distributors.

Where it is at all difficult to get the desired stand, extra seed should be planted. Thinning will usually result in greater economy than leaving a defective stand or replanting.

Five distinct functions of cultivation are specified. Desirable types of cultivators are illustrated and methods of using them described. In connection with cultivation, means for a more practicable way of distributing commercial fertilizer are suggested and special devices for doing so are illustrated.

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Corn in the Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 219.)
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Corn, Milo, and Kafir in the Southern Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 242.) Price, 5 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 730 JUNE 2, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

BUTTON CLOVER.

By ROLAND McKEE, *Assistant Agrostologist, Forage-Crop Investigations.*

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INTRODUCTION.

Button clover[1] is native to the Mediterranean region of the Old World and was introduced into the United States in 1899 by the Office of Foreign Seed and Plant Introduction. Since then, several other small lots of seed of this clover have been obtained from this same region, but practically all the experimental work done has been with seed increased from an introduction made in 1902.[2] Button clover has been tested most extensively in California, where it has proved especially well adapted. In the Southern States it has not been tested extensively enough to determine definitely its value, but the work done indicates that it can perhaps be used successfully in all the milder sections now growing the spotted or southern bur clover.

DESCRIPTION OF BUTTON CLOVER.

Button clover is an annual. It makes a decumbent or trailing growth, ascending only when in a thick stand. The stems attain a length of 24 to 48 inches and are rather slender and branched but little. The plants produce a number of stems, but in this respect they vary considerably, depending mainly on the thickness of the stand. Usually the stems are quite leafy throughout their entire length. There is a marked similarity of the leaves to those of ordinary clover, the leaflets being rotund or obovate. In general, the flowers resemble those of alfalfa, but differ in being a little smaller and borne two in a place instead of many and in being yellow instead of purple, the most common color in alfalfa. The seed is about the size of alfalfa seed and is borne in a tightly coiled lentil-shaped pod one-half to 1 inch in diameter. (Fig. 1.)

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[1] *Medicago orbicularis.*

[2] This introduction is S. P. I. No. 10725, being seed secured in Algeria by Mr. T. H. Kearney.

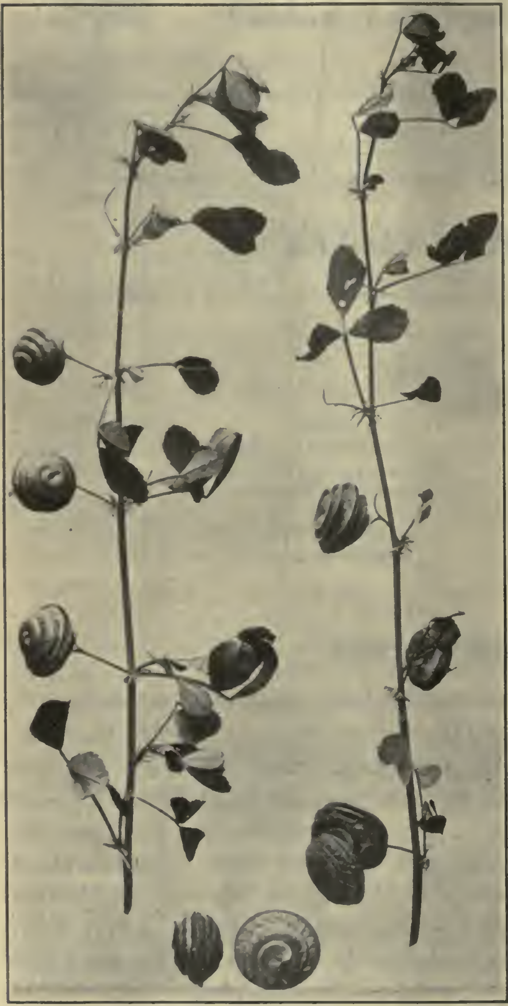

FIG. 1.—Stems of button clover, showing the large spineless pods. (One-half natural size.)

SIMILAR SPECIES.

While button clover is but little known in most parts of the United States, there are several similar and closely related plants that are quite common and well known. The toothed or California bur clover[1] and the spotted or southern bur clover[2] are well-known species that are closely related to button clover and resemble it in general appearance and manner of growth. The most noticeable difference between the button clover and the others mentioned is in the pods or burs. The burs of button clover are large and spineless, while the others have comparatively small and spiny burs. Yellow trefoil[3] and alfalfa[4] belong to the same genus of plants as button clover, and while yellow trefoil is more or less like button clover in its manner of growth and general requirements alfalfa is quite different.

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[1] *Medicago hispida denticulata.*

[2] *Medicago arabica.*

[3] *Medicago lupulina.*

[4] *Medicago sativa.*

CLIMATIC REQUIREMENTS.

While button clover, if sown in the spring, can be grown as a summer crop in sections having cold winters, it can be grown to advantage only where the climatic conditions are so mild that it can be used as a winter annual. As such it is not adapted to sections having a winter temperature below 18° F. above zero, and it will not establish itself and reproduce spontaneously under a much lower temperature. Aside from being unable to withstand extreme cold, button clover does not do well in extreme heat. A growing period having no extremes of temperature is essential for the best results. The accompanying map (fig. 2) shows the areas of the United States in which temperature conditions are favorable to this crop.

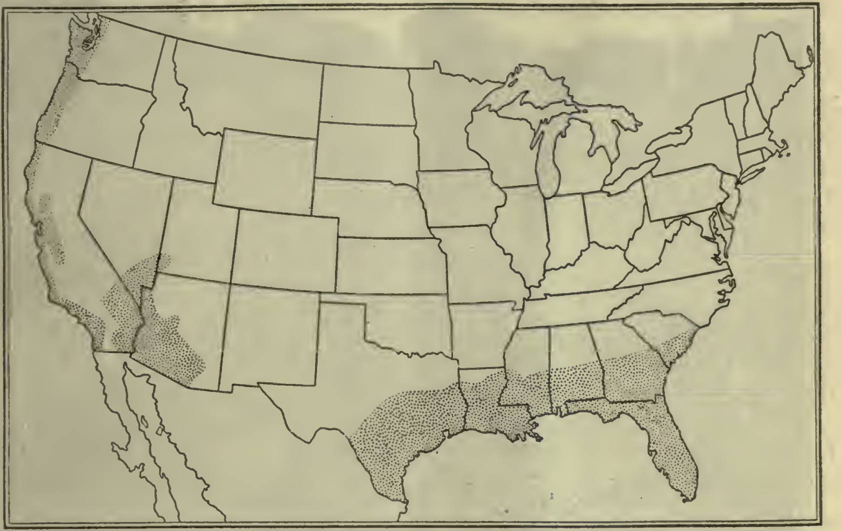

FIG. 2.—Outline map of the United States, the shaded portion showing the areas where the climatic conditions are favorable to the production of button clover.

SOIL AND MOISTURE REQUIREMENTS.

In testing button clover in comparison with spotted and toothed bur clovers it has been found that its requirements as to soil and moisture conditions are practically the same as for those crops. While it does best on fairly well drained rich loam soil, it can also be grown on almost any soil containing sufficient moisture. It will make a fair growth under rather arid conditions, but in the dry foothill pastures of California it has done no better than the common toothed bur clover. On heavy, moist, low lands it has done well, equaling spotted and toothed bur clovers.

VALUE FOR PASTURAGE.

The principal value of button clover is for pasturage. It is well suited for this purpose, and in the bur-clover sections or sections having a mild winter climate it will make a valuable addition to the present pasture plants. Under favorable conditions it makes a heavy growth (fig. 3) and produces much more seed than bur clover. Under less favorable conditions the growth is correspondingly less, but it will succeed wherever bur clover does well. Button clover makes good pasturage when in the green state and, like bur clover, it is readily eaten by live stock. Its unique value lies in the fact that it produces a larger quantity of seed than the spotted or toothed bur clover and that it has no spines on the pod, or bur. The pods ripen in early summer and drop from the vines. In their ripened state they are then available at any time as food for stock. This is especially true in the southwestern portion of the United States, where the summer season is practically without rainfall. Button clover, being similar to bur clover and alfalfa, may sometimes cause bloat in cattle and sheep when fed in the green state, and care should be taken in turning stock into such fields for the first time. This trouble is most likely to be experienced in early spring, when the plants are very succulent. It is also essential that button-clover pastures should

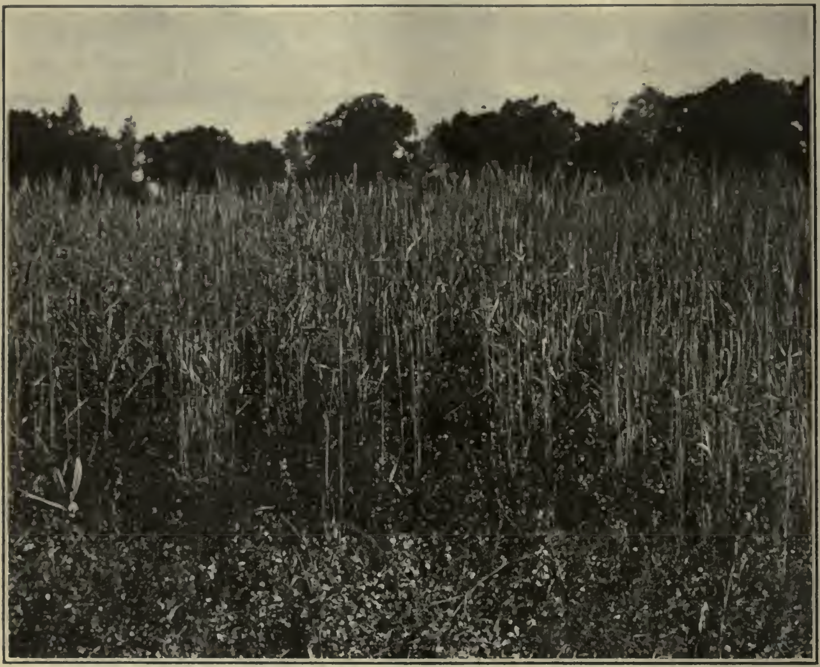

FIG. 3.—A field showing a heavy growth of button clover mixed with wheat at Chico, Cal.

not be grazed too closely in the late spring, as with close pasturing, especially with sheep, most, if not all, the large burs will be eaten in the green state and but few, if any, of the seeds will reach maturity. In order to maintain a stand of button clover, some of the pods must be allowed to mature each season. Button clover is to be preferred to spotted or toothed bur clover for introduction on ranges where sheep are pastured. The great loss of wool occasioned by the spiny burs of the last two species getting into the fleece is evidence, to any one familiar with such conditions, of the value of a species with a spineless pod.

The superior value of button clover has been recognized for some time in Australia, where it is now quite common in several regions. In 1905 the advantage of spineless bur clover was pointed out by calling attention to the great loss sustained by the wool producer on account of spiny burs.[1] Fleeces from districts producing spiny bur clovers in abundance often contain as much as 25 to 30 per cent of burs. This not only means loss by reason of lower prices paid for the burry product, but also on account of extra freight. The Agricultural Journal of Cape Colony, South Africa, for September 7, 1893,[2] reported the receipt of seeds of button clover and snail clover, a similar species, from Baron von Mueller, who, in transmitting them, wrote: "They are annual, but produce an immense number of fruits, which the sheep lick up and eat when pasturage fails. I have gathered as many as 1,400 seeds from a single plant." In January, 1894, J. H. Maiden[3] referred to Von Mueller's statement regarding these plants and states that "he [Von Mueller] has been the means of distributing both plants in many Australian localities in which it now flourishes." Spiny bur clover, however, has spread more rapidly in Australia than button clover, but the latter is not uncommon, occurring abundantly in various localities, and seed is now advertised for sale by Australian seedsmen.

VALUE FOR HAY AND GREEN MANURE.

Button clover makes good hay that is readily eaten by all kinds of stock. For hay of the best quality, it should be cut when most of the pods are still green but well developed and just before the leaves begin to fall. When allowed to become more mature, many of the pods as well as the leaves are lost in handling and the value of the hay is greatly reduced. In growing for hay, a supporting crop of oats or barley or some other grain should be sown with the button clover, in order to facilitate cutting. The decumbent habit of the plant makes this desirable, and aside from this the mixture, consisting of grain and button clover, makes excellent feed. The use of button clover for hay production will no doubt be very limited, as there are other legume crops that are more desirable for this purpose. However, its habit of growth and not its feeding value as hay is the factor limiting its use. The value of button clover for green manuring is about the same as toothed and spotted bur clovers.

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[1] Burrless clover. *In* Agr. Gaz. N. S. Wales, vol. 16, pt. 1, pp. 76–78, illus. 1905.

[2] Useful fodder plants. *In* Agr. Jour. Cape Colony, vol. 6, no. 18, pp. 335–336. 1893.

[3] Maiden, J. H. Two fodder plants interesting to the woolgrower. *In* Agr. Gaz. N. S. Wales, vol. 5, pt. 1, pp. 5–6, 1 pl. 1894.

INOCULATION.

It is common to find nodules of various forms on the roots of nearly all legumes. These nodules are caused by bacteria or microorganisms that live upon the roots of the plants. The bacteria are beneficial to the plant upon which they live, as they take nitrogen direct from the air and make it available for the use of the plant as food. With many plants it is essential for their best growth that these bacteria be present, and in soils where they do not occur naturally or in sufficient numbers they must be supplied by artificial means when a crop is grown for the first time. The supplying of these bacteria to a soil is known as inoculation. In the parts of the Pacific Coast States where bur clover is now common, inoculation is not necessary for button clover. In places where bur clover does not occur, and particularly in places where alfalfa does not do well, inoculation is usually essential. In the Southern and Gulf Coast States inoculation is advised except on land that has previously grown bur clover.

One of the easiest methods of inoculation is to mix a small amount of soil from an old bur-clover field with the seed, whether hulled or in the bur, immediately preceding planting. The quantity of soil used need be only a mere dusting. Inoculation can also be accomplished by scattering soil from an old bur-clover field over the area to be seeded. This should be done immediately prior to sowing the seed. Sowing seed in the bur seems also to insure inoculation, and for this reason it is commonly practiced in the Gulf Coast States with spotted or southern bur clover. Open and loamy soils are the most easily inoculated, and it is recommended that in growing button clover on a place for the first time an old garden patch or other well-prepared and manured piece of land be selected. In the absence of inoculated soil, inoculation may be secured by the use of artificial cultures.

TIME OF SEEDING.

In sections having a mild winter climate, button clover should be sown in the fall. Where summer rains occur, as in the Southern States, the seeding should be done about the first of September. Early summer seeding in the Cotton States is not advisable, as the young plants starting at that time are liable to suffer from drought, and where a heavy growth is made the plants tend to mature and die rather than continue growth through the winter. In California, where dry weather prevails throughout the summer, the seed may be sown at any time before the fall rains begin. When it is desirable to start the seed in the fall with irrigation, the seeding should be done about the first of October. The object is to sow the seed so late that a subsequent irrigation will not be necessary.

ESTABLISHING IN PASTURES.

In sowing button clover in pastures, little more can be done than to scatter the seed in the most favorable places, but attention should be paid to the time of seeding and also to inoculation. In pastures that can be cultivated, a working of the soil prior to sowing will, perhaps, be found advantageous in establishing a stand, but except on good lands this will hardly be profitable. The soil should be worked very lightly, if at all, after seeding, as the seed of button clover will not germinate readily when given more than a very light covering. On most pasture lands about all that can be done profitably is to sow the seed broadcast and allow it to compete with the other pasture plants. In pasturing button clover, care should be taken to see that seed is allowed to mature each season, or at least every other year, in order to maintain the stand.

GROWING FOR SEED.

The growing of button clover as a seed crop on a large scale is most practicable in sections having a continuous dry summer. California, apparently, has more favorable conditions for growing button-clover seed than any other State. Before seeding, the land should be put in as good condition as possible by plowing and harrowing, and if the seed is to be harvested by sweeping or by a similar method the field should be run over with a float or roller to leave a smooth surface, in order to facilitate the harvest. If a drill is used to sow the seed, the ground should be especially well firmed, as otherwise the seed will be planted too deep. The clean seed may be sown broadcast or by using an ordinary grain drill with a press-wheel attachment. Special care should be taken to give the seed but a light covering. The press-wheel attachment is necessary for the best success when a drill is used. In general, broadcast seeding will perhaps be found the most satisfactory. A light harrowing is all that is necessary to cover the seed sufficiently. When the land is left with light furrow markings, such as are made by a large-toothed harrow, the seed not covered by the harrow at the time of seeding will fall into these small furrows and be covered by the washing of subsequent rains. Good stands have been secured by this method without covering the seed at all at the time of sowing, and it probably will be found satisfactory in all sections where rains are frequent at seeding time.

HARVESTING AND THRASHING.

The harvesting of button-clover seed is rather difficult on account of the decumbent habit of the plant and because the burs fall from the vines so easily. The use of ordinary farm machinery has not been found satisfactory, and sweeping the burs together, a method used in various sections with spotted and toothed bur clovers, is perhaps the most satisfactory for general use. The practice when harvesting in this way is to allow the seed to ripen thoroughly and then to cut the vines with an ordinary mowing machine and rake them into windrows. The burs are then swept together with large barn brooms and hauled from the field. The burs gathered in this manner are mixed with more or less gravel and other foreign substances, which must be removed before the seed can be hulled satisfactorily or used in the bur. This separation is accomplished by the use of handbarrow screens and an ordinary fanning mill regulated to blow the burs over, or if running water is handy, a quicker and more satisfactory method is to throw the burs into the water. All heavy substances sink, and the burs and lighter substances are then dipped from the stream. To facilitate this method of separation the channel of the stream should be narrowed in the shape of an open V, which generally aids in collecting the cleaned burs. To dip the burs from the water, a large handbarrow with a bottom made of wire netting has been found very satisfactory. The burs are spread on canvas to dry, after which they are ready for the huller. An ordinary clover huller separates the seed satisfactorily.

YIELD OF SEED.

In comparison with the spotted and toothed bur clovers, button clover produces a large amount of seed. In Table I are given the yields secured at Chico, Cal., from plantings one-twentieth of an acre or larger. In the 1908 test the plats were grown without irrigation. In 1909 and 1910 the plats were irrigated in the fall prior to planting, but no subsequent irrigation was given. The comparatively large yields of the button clover have been very consistent in all of the tests. Hulled seed of button clover weighs about the same as alfalfa seed—60 pounds to the bushel. Seeds in the bur weigh about 8 pounds to the bushel and a bushel of burs contains about 2½ pounds of seed.

TABLE I.—*Yield of seed per acre of button clover and toothed bur clover at Chico, Cal., from 1908 to 1911, inclusive.*

Kind of clover.	Yield per acre of hulled seed (pounds).			
	1908	1909	1910	1911
Button clover	860	790	1,160	947
Toothed bur clover	407	407	255	....

LONGEVITY OF SEED.

The length of life of the seed of button clover no doubt varies somewhat, depending upon the conditions under which it is kept. Tests made in various years with several lots of hulled seed stored in ordinary warehouses show that after three years the percentage of germination will be reduced to about one-half. Tests made in 1915 with seed grown in 1912 showed a germination of 58 per cent, with 2 per cent of hard seed. Seed grown in 1907 germinated 49.5 per cent, with 5 per cent of hard seed, when 4 years old, and 29.5 per cent, with 7 per cent of hard seed, when 7 years old. In 1911 a test made with seed grown the previous year gave a germination of 91 per cent, with 4 per cent of hard seed.

CONCLUSIONS.

Button clover is an annual plant similar to spotted and toothed bur clovers.

It is native to the Mediterranean region of the Old World, whence it was introduced into the United States.

A mild climate with a winter temperature not lower than 18° F. above zero is necessary for its best development.

It is not exacting as to soil and moisture requirements and succeeds under quite varied conditions.

As a pasture plant, button clover is especially valuable in the milder districts of the southwestern United States, where it is to be preferred to spotted and toothed bur clovers.

It is easily established in pastures, as it needs no other treatment than the scattering of the seed where desired.

Inoculation is essential in districts where the nodule-forming bacteria are not already in the soil.

Button clover makes good hay, but it is difficult to handle as a hay crop on account of its decumbent habit.

A good seed crop is usually produced, but the harvesting and thrashing of the crop are made difficult on account of the pods dropping easily from the stems.

The value of button clover for green-manuring purposes is practically the same as spotted and toothed bur clovers.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 731 MAY 23, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE TRUE ARMY WORM[1] AND ITS CONTROL.

By W. R. WALTON, *Entomological Assistant, Cereal and Forage Insect Investigations.*

INTRODUCTION.

This publication is designed to convey to the farmer, in a brief and simple manner, the natural history of the true army worm, a caterpillar which from time to time becomes enormously destructive to growing cereals, and sometimes to forage crops; to give him a summary of the information necessary for its control; and especially to urge upon him the necessity for constant vigilance in the combat with this insect.

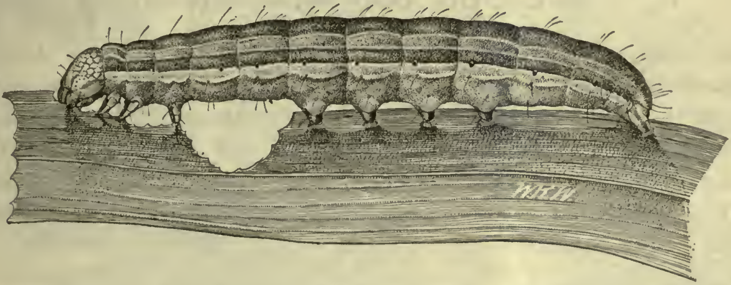

FIG. 1.—The true army worm: Full-grown larva or caterpillar. Enlarged. (Original.)

The true army worm (fig. 1) is often confused in the public mind with the fall army worm,[2] "overflow worm," or "grass worm" as it is known in some of the extreme Southern States. The latter insect always originates in the South and travels northward as the summer advances. The western army cutworm[1] also is occasionally mistaken for the true army worm, but it occurs in destructive abundance only throughout the regions west of the Mississippi River. Both of the latter insects will be treated in a separate publication.

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[1] (*Heliophila*) *Cirphis unipuncta* Haw.; order Lepidoptera, family Noctuidae.

[2] *Laphygma frugiperda* S. & A.

NOTE.—This bulletin is of general interest to crop growers everywhere, and especially east of the Rocky Mountains.

GENERAL DESCRIPTION.

The fully developed parent of the army worm (figs. 2, *a*, and 5) is a moth or "miller" measuring about 1½ inches across the expanded wings. It is brownish-gray in color, having a single small white spot near the center of the front pair of wings, the hind wings being somewhat darker along the hind edges. Although these parents of the worm sometimes are very numerous, they fly only at night and are therefore often entirely overlooked by the farmer. The stage of the insect most familiar to him is the full-grown, striped, nearly naked caterpillar (figs. 1 and 2, *b*), usually discovered in the act of devouring his crops and in most cases after having already destroyed the greater portion of the infested crop.

WHERE THE ARMY WORM OCCURS.

The true army worm is probably a native of North America, although it is also found in South America. It occurs throughout most of the United States east of the Rocky Mountains, including the States bordering the western banks of the Mississippi and the Missouri Rivers. It also has been found in New Mexico, Arizona, and California. It is not known from the Rocky Mountain Plateau region. (See fig. 3.)

ECONOMIC IMPORTANCE AND MANNER OF INJURY.

The loss in money to the farmer by army worms in the past has been exceedingly great, and although no exact estimate is possible, it is safe to say that in the Eastern States alone many millions of dollars' worth of grain and forage crops have disappeared down their throats during the past 30 years.

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[1] (*Chorizagrotis*) *Euxoa auxiliaris* Grote.

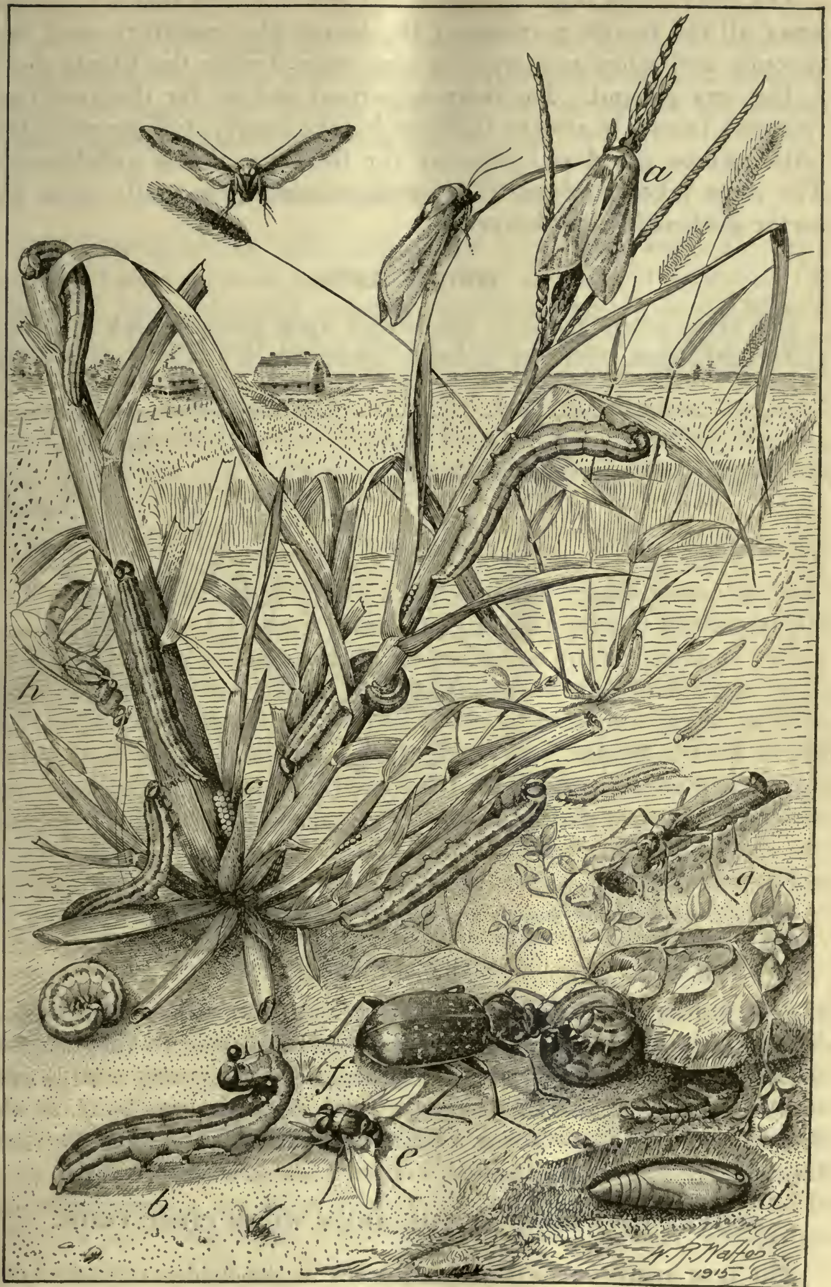

FIG. 2.—Stages and work of the true army worm and some of its insect enemies: *a*, Parent or moth; *b*, full-grown larva; *c*, eggs; *d*, pupa in soil; *e*, parasitic fly, *Winthemia quadripustulata*, laying its eggs on an army worm; *f*, a ground beetle, *Calosoma calidum*, preying upon an army worm, and, at right, Calosoma larva emerging from burrow; *g*, a digger wasp, *Sphex* sp., carrying an army worm to its burrow; *h*, *Enicospilus purgatus*, a wasplike parasite of the army worm. All about natural size. (Original.)

The army worm injures crops in but one way, and that is by eating away all the tender portions of the leaves, the immature seed, and sprouts, and when numerous it may even devour the plants down to the very ground. The more important and by far the most conspicuous injury is always inflicted by the nearly full-grown caterpillar, whose greed and capacity for food are almost unbelievable. The pupa takes no food. The moth subsists principally upon the nectar gathered from flowers.

FOOD PLANTS.

The army worm feeds by preference upon grasses, both wild and cultivated; next, upon the grasslike grains, such as the several varieties of millet, which suffer severely during outbreaks of the insect. Wheat in its unripe stages, corn, oats, and rye seem to be preferred in the order named. In some portions of the country alfalfa also suffers injury; apparently damage to this crop occurs only in the Southwestern States—Texas, Oklahoma, New Mexico, and Arizona. Occasionally clover is attacked, but such occurrences are rare.

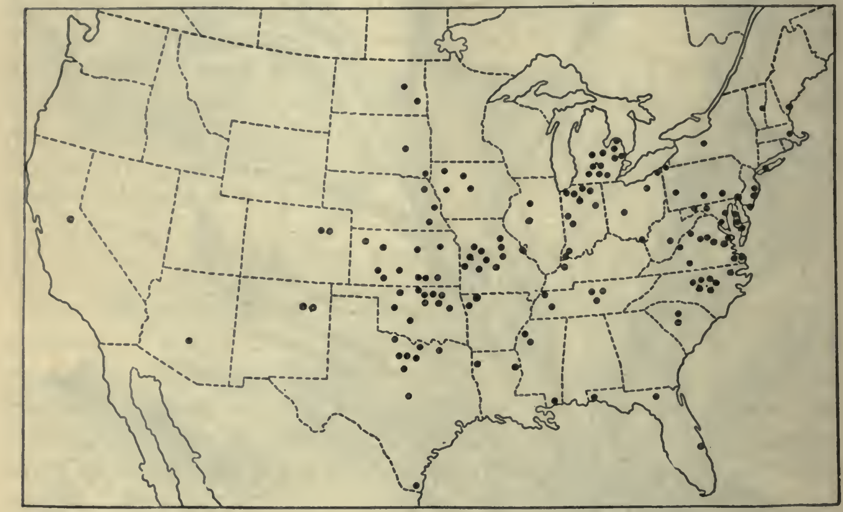

FIG. 3.—Map showing localities in the United States in which the true army worm has been destructive. (Original.)

WHERE INVASIONS OF THE ARMY WORM COME FROM.

The true army worm usually appears in the fields very suddenly, and it seems quite certain that the moths at times fly in great numbers for many miles, in the direction of the prevailing winds, and alight in a body to deposit their eggs at some place favorable to the development of their offspring. This fact accounts for the sudden appearance of the army worm in regions far removed from any known source of infestation. The moth, however, seems to be present in small numbers, over most of the area in which it occurs, during a portion of every year, but this fact does not account for the sudden great invasions which occur from time to time.

WHEN INVASIONS MAY BE EXPECTED.

Generally speaking, outbreaks of the true army worm are more common following cold, backward springs and should be looked for first in neglected portions of fields upon which rank growths of wild grasses or lodged and fallen unripe grain are to be found. These should be examined frequently and closely, especially during late April, May, June, and early July, in order to discover the small greenish caterpillars, which may be found in great numbers feeding near the surface of the ground under the sheltering, overhanging leaf blades.

LIFE HISTORY.

The army worm, like many other common insect pests, has four forms or stages, as follows: First, the parent moths or millers, which seek out rankly growing grass or grasslike grains, such as millet, upon which they lay their eggs (fig. 2, *c*). From these eggs hatch the little caterpillars or "worms," which feed and grow rapidly. When full grown they shed their skins and change to the brown pupa or resting stage, usually beneath the surface of the soil. From these pupæ come the parent moths, which in turn mate and lay their eggs, thus providing for another brood of caterpillars. There are usually three generations of caterpillars in any one year, but seldom or never two successive outbreaks in any given locality.

THE EGG STAGE.

The eggs are laid by the parent moths at night, usually in the folded blades or under the leaf sheaths of grains and grasses (fig. 2, *c*). These resemble small white beads, each considerably smaller than the head of a common pin, and are deposited in masses or rows on the plants selected. Moist or shaded spots usually are chosen for this purpose by the moths, many of which seem to congregate and lay their eggs in the same locality. These eggs hatch in from 8 to 10 days and from them come the very small greenish caterpillars or "worms."

THE CATERPILLAR OR LARVAL STAGE.

When the caterpillars are first hatched they are very tiny and, although countless thousands of them may be present, they consume, at this time, comparatively little food. Feeding near the ground, sheltered from view by the overhanging grain or grasses, they almost invariably escape the notice of the farmer. If the colony of worms can be discovered at this stage of their growth the infestation usually can be stamped out completely by prompt and vigorous measures, such as spraying with arsenicals or covering with straw and burning over the infested spot.

As the young worms grow and feed, their skins become too small for them, so presently they split and are shed, and the caterpillars begin feeding more greedily than ever. This occurs several times during the life of the caterpillar, until the worm becomes full grown. The time required for full growth is from 3 to 4 weeks. The full-grown army worm (figs. 1 and 2, *b*) is a nearly naked, smooth, striped caterpillar, about 1½ inches long. Its general color is usually greenish, and the stripes, one along each side and a broad one down the center of the back, are dark and often nearly black. The stripe along the back usually has a fine, light-colored, broken stripe running down its center. The color of the body between the dark stripes varies from greenish to reddish brown. The head is greenish brown speckled with black.

When an army of these worms is at work in a field the champing of their jaws is plainly to be heard, as they greedily devour every blade in sight. In this stage the army worm frequently consumes all of the food supply near the place where it has developed from the egg. When such is the case the caterpillars mass together and crawl away in a body in search of other food. It is this habit which has gained for the insect the popular name of "army worm." The massing together of the worms affords the farmer an opportunity of destroying them in great quantities by mechanical methods described on a following page of this publication. When the full-grown caterpillars cease feeding they usually burrow into the soil to the depth of a few inches and by dint of twisting and turning form a cavity or cell therein. The worm then begins to shrink and shorten, after which the skin splits and is shed and the pupa appears beneath it. When the worms are very numerous many of them pupate on the surface of the ground, hidden under clods, boards, or bunches of dried grass and fallen grain.

THE PUPA OR RESTING STAGE.

The pupa (figs. 2, *d*, and 4) or resting stage of the true army worm resembles a date seed in size and shape, but is more pointed at one end. In color it is at first a reddish or chestnut brown, becoming almost black as the time for emergence of the moth approaches. Its skin or covering is smooth and tough, and the pupa is unable to move any portion of its body excepting its tail, which it wriggles vigorously upon being disturbed. If the soil in which the pupæ are resting be lightly cultivated during this time and the pupæ thrown to the surface, most of them will be killed by exposure to the weather, crushed by the cultivating implements, or eaten during the day by birds or at night by skunks which roam the fields and consume great quantities of such food.

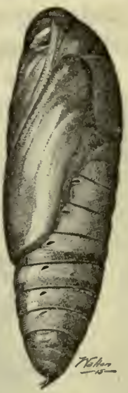

Fig. 4.—The true army worm: Pupa. Enlarged. (Original.)

THE PARENT OR MOTH STAGE.

When the moth (figs. 2, *a* and 5) crawls forth from the pupal case it has not yet developed its wings, which are crumpled and folded in pad-like masses on each side of its back. It usually crawls up the stem of some plant and begins to expand its wings, waving them back and forth slowly for about an hour, by which time they are completely developed and the insect is capable of flying. However, if undisturbed, the moths will usually remain at rest for several hours before flying away to mate and lay their eggs. It takes from 7 to 8 weeks for the insect to develop from the egg to the adult or moth.

After the moths have expanded their wings they do not grow any larger; the small moths are not the young of larger moths, but the male moth or parent of the army worm is usually considerably smaller than the female.

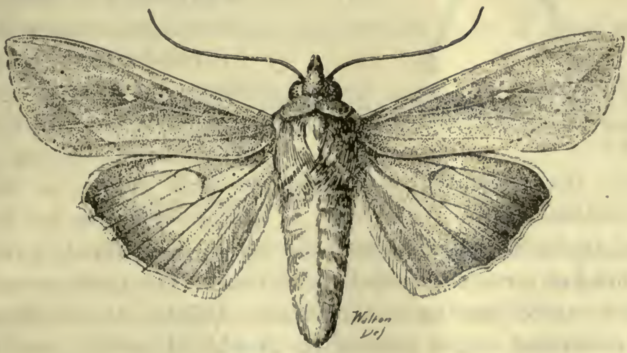

Fig. 5.—The true army worm: Parent or moth. Enlarged. (Original.)

The army worm moth is strongly attracted to lights at night and frequently swarms of these moths are seen about lights out of doors shortly before an outbreak of the army worm. Farmers would therefore do well to learn to recognize the moth at sight, as in this way they could be warned of the probable subsequent injurious abundance of the caterpillar. The moths may readily be known by their plain brownish-gray appearance and the presence of a single very small, almost pure white speck or spot near the center of each of the front wings (see figs. 2, *a* and 5). The moths seldom or never lay their eggs near the spot where they have developed and frequently fly for many miles before doing so. Thus there are seldom two successive outbreaks during the year in any given locality. It is not yet definitely known where or how the army worm lives over the winter, but the indications are that it does so in the partially grown caterpillar stage.

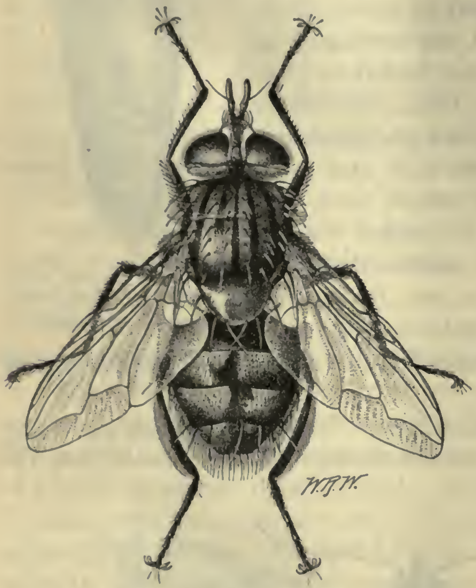

FIG. 6.—*Winthemia quadripustulata*, a fly parasitic on the true army worm: Adult. Much enlarged. (Original.)

HISTORY OF THE ARMY WORM IN THE UNITED STATES.

The army worm has been known as a serious pest on cereal and forage crops in the United States since early colonial times. As early as the year 1632 it is recorded as injuring corn in New England by Peter Kalm, a Swedish naturalist who traveled in this country. In the year 1743 a great outbreak of the army worm is recorded as having occurred throughout that portion of the country now known as the North Atlantic States. From then down to the present time the insect has hampered agriculture and robbed the farmer mercilessly at comparatively short but irregular intervals of time. The most recent serious invasion occurred during the summer of 1914, at which time the entire agricultural region east of the Rocky Mountains and north of the Gulf States suffered to a greater or less degree. From the past history of the insect the farmer may confidently expect to be compelled to cope with it from time to time, and he should ever be on the alert during the spring and early summer months in order to discover the pest before it has made serious inroads upon his crops.

NATURAL ENEMIES.

Most fortunately for the farmer, the army worm has many natural enemies among the native insects, reptiles, birds, and mammals.

INSECT ENEMIES.

One of the commonest and most effective of its insect foes is a medium-sized gray fly[1] (fig. 6), closely resembling, and slightly larger than, the house fly. This parasite sticks its eggs fast to the skin of the caterpillar (fig. 2, *b* and *e*) and the quickly hatching maggots bore through the skin into the flesh, where they soon devour the entire inside portions of the army worm's body. These flies multiply rapidly and often become so numerous as to control the army worm completely in a given locality.

Another common insect foe is a very small wasplike creature (fig. 7),[2] which pierces the caterpillar with its sting or ovipositor, laying its eggs inside the army worm's body, where they quickly hatch and, the maggots having eaten their fill, bore their way outward and spin little silken cocoons in a mass together, somewhat resembling grains of rice entangled in a mass of cotton. This parasite is also sometimes numerous enough to be of great service in controlling the pest.

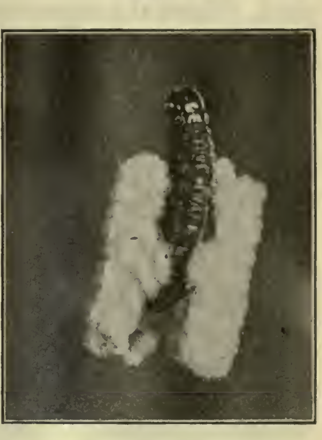

FIG. 7.—Larva of the army worm surrounded by silken cocoons of the wasplike parasite *Apanteles militaris*. About natural size. (Original.)

Several other insect enemies serve more or less efficiently in combating the army worm. Some of these are shown in figure 2, *f*, *g*, *h*.[3]

WILD BIRDS AND OTHER ENEMIES.

According to the records of the United States Biological Survey, more than 40 species of native wild birds are known to eat the army worm in its various stages. Among the most important of these are the following: Crow blackbird or grackle, yellow-headed blackbird, chipping sparrow, bluebird, prairie hen, and European starling. Domestic fowls of all kinds will greedily devour the caterpillars and pupæ if allowed to roam over infested fields. Skunks and toads also undoubtedly eat thousands of the army worms, both caterpillars and pupæ. These birds and other animals should therefore be encouraged and protected by the farmer by all possible means.

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[1] *Winthemia quadripustulata* Fab.

[2] *Apanteles militaris* Say.

[3] *Calosoma Calidum* Fab., (*Ammophila*) *Sphex* sp., and *Enicospilus purgatus* Say.

CONTROL MEASURES.

WATCHFULNESS AS A FACTOR.

The importance of watchfulness, on the part of the farmer, as a factor in combating the army worm can not be too greatly emphasized. Upon the discovery of the pest in its younger stages depends very largely the possibility of stamping out an infestation before serious injury to crops has occurred. The farmer should examine his meadows frequently during the spring and early summer months, particularly those planted to timothy, bluegrass, and especially millet. He should not be satisfied with looking merely at the surface of the stand; the thicker and longer the growth, the greater the danger from the army-worm. The grass or grain should be parted with the hands in various parts of the field and the lower portions of the growth closely examined, in order to discover the presence of the small, greenish caterpillars, and if such be found in any number the area covered by the infestation should be determined and vigorous action taken at once to destroy the worms before they become large enough to begin their journey to other portions of the farm. If the infested spot be small, the grass or grain can be mowed off and straw scattered over the spot and burned, thus destroying the worms. If the caterpillars have become distributed over a considerable area, this can be marked off by stakes and the crop sprayed heavily with a mixture of Paris green at the rate of 1 pound to 50 gallons of water. In case this poison is used, care should be exercised in preventing stock from gaining access to the poisoned grass or grain and being injured or killed by eating it. It is far better to sacrifice a portion of the crop, if the destruction of the pest can be accomplished thereby, because if the army worms are not destroyed they will take the crop anyway and probably devastate other portions of the farm.

POISONED BAITS.

Poisoned baits of varying composition have long been used as a means of destroying the many different species of cutworms and also the army worm. An efficient bait of this kind may be prepared and used as follows: To 50 pounds of wheat bran and 1 pound of Paris green or 2 pounds of arsenate of lead add the juice of one-half dozen oranges or lemons. Then bring the mass to a stiff dough by adding low-grade molasses or sirup, preferably the former, and scatter the mixture broadcast in small pieces throughout the infested field. This poisoned bait may be safely used in alfalfa and cornfields where it is desired, if possible, to save the crop for forage purposes.

MECHANICAL MEASURES.

In case the worms are not discovered until they have begun to travel in a mass, they can usually be destroyed by furrowing or ditching (fig. 8) completely around the infested area. In attempting to cross such ditches the worms will fall into them and can easily be destroyed by crushing them with a log dragged back and forth through the ditch or furrow. If shallow post holes are sunk in the bottom of the ditch at intervals of about 20 feet, the worms will crawl along the ditch bottoms and fall into the holes, where they may be destroyed by crushing or other means. If the subsoil be of such a nature that water penetrates it but slowly, the post holes may be partially filled with water, on the top of which a layer of coal oil or petroleum may be poured. Upon falling into such holes, the worms are almost immediately destroyed without further action on the part of the farmer.

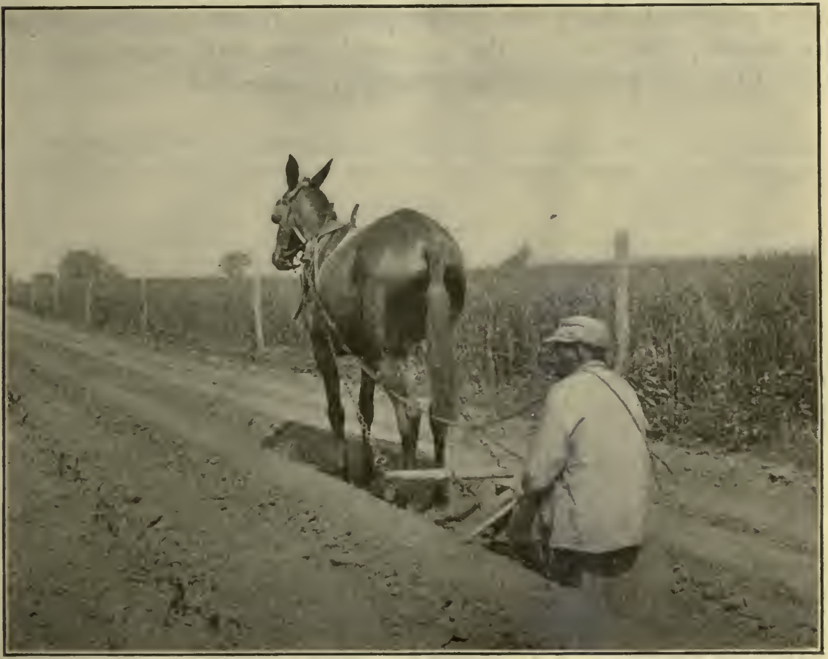

FIG. 8.—Ditch prepared to entrap marching army worms. A log, dragged back and forth through the ditch, crushes the worms which have falled into it. (Original.)

SUMMARY OF CONTROL MEASURES.

(1) Watch fields of growing grass and grain carefully, especially the meadows, during the spring and early summer months, in order

to discover the army worms before they have a chance to become full grown and spread over the entire farm. When the worms are discovered at work do not lose a minute, but attack them vigorously by means of the measures outlined in the foregoing pages.

(2) In case the worms are crawling in a body, surround them with a furrow or ditch and crush them with a log drag as they fall into it.

(3) Poison them by spraying crops not intended for forage purposes with 1 pound of Paris green to 50 gallons of water, or with 2 pounds of arsenate of lead to 50 gallons of water. In case the Paris green is used on tender plants, like corn, 2 pounds of freshly slaked lime should be added to 50 gallons of the mixture. This is to prevent burning the tender plants. Where spraying is not practicable, the use of the poisoned bran bait, mentioned on page 10 of this publication, is strongly recommended.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 732 MAY 29, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

MARQUIS WHEAT.

By CARLETON R. BALL, *Agronomist in Charge of Western Wheat Investigations*, and J. ALLEN CLARK, *Scientific Assistant in Western Wheat Investigations*.

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INTRODUCTION.

Marquis wheat has aroused much interest in the United States during the past three or four years. Farmers and also millers, bankers, and real-estate dealers have had their attention attracted to it. This interest was first stimulated by items in the papers stating that Marquis wheat had taken the first prize for hard spring wheat at certain expositions. Statements were published also of high yields made by this variety in the Provinces of Manitoba and Saskatchewan in Canada.

WHAT IS MARQUIS WHEAT?

The variety called Marquis is a hybrid wheat produced by Dr. A. P. Saunders and Dr. C. E. Saunders, cerealists of the Central Experimental Farm at Ottawa, Canada.

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HISTORY.

Marquis wheat is one of the descendants of a cross made in or about 1892. The female parent was a wheat from India, called Hard Red Calcutta. The male parent was the widely grown Red Fife wheat of Canada.

The different forms resulting from this cross were separated in 1903 at Ottawa, and each was grown by itself in 1904. One selection having desirable plant characters was named Marquis at some time between 1905 and 1907.

The good milling qualities of this variety became apparent by the end of 1906, and it was sent out to Manitoba for testing in 1907. Wheat rust was very bad in 1907 in the wheat-growing Prairie Provinces. The earliness of this variety enabled it partly to escape the rust. It soon became a leading variety in Manitoba and Saskatchewan.

The yields of Marquis wheat at agricultural experiment stations in these Provinces were 13.5 to 38 per cent higher than the yields of Red Fife during the eight years, 1907 to 1914, inclusive.

DESCRIPTION.

The Marquis is a beardless spring wheat, with hairless, white (greenish white) chaff or glumes, and a hard red kernel. In appearance it closely resembles the Fife wheats of our northern Great Plains States and is therefore included in the Fife group (fig. 1).

The plants are of only medium height, ranging from 28 to 48 inches, according to season. They generally are 2 to 4 inches shorter than those of the Glyndon or Power varieties. The heads are short, varying from 2½ to 4 inches, and averaging one-half to 1 inch shorter than other varieties of Fife wheat. The chaff or glumes also are short and broad. Two or three short awns or beards usually are found at the tip of the head, as in other beardless wheats. The short straw is stiff and stands up well. The seed does not shatter.

The kernels of other Fife wheats are short and broad, but those of the Marquis are even more so. They average about one-twentieth of an inch shorter than those of Fife and Bluestem wheats (fig. 2). The crease is deep and broad.

The Marquis is an early variety, ripening from 98 to 135 days after sowing, varying with the season and locality. The average length of its growing period in the northern Great Plains is about 115 days. This makes it three or four days earlier than most of the other Fife varieties. Because of its earliness it escapes to some extent the drought of dry years, the rust and fall rains of wet seasons, and also the early fall frosts. These are the characteristics which have made it especially valuable in the Prairie Provinces of

Canada. The growing season lengthens as one passes southward into the United States, and earliness is no longer so great an advantage.

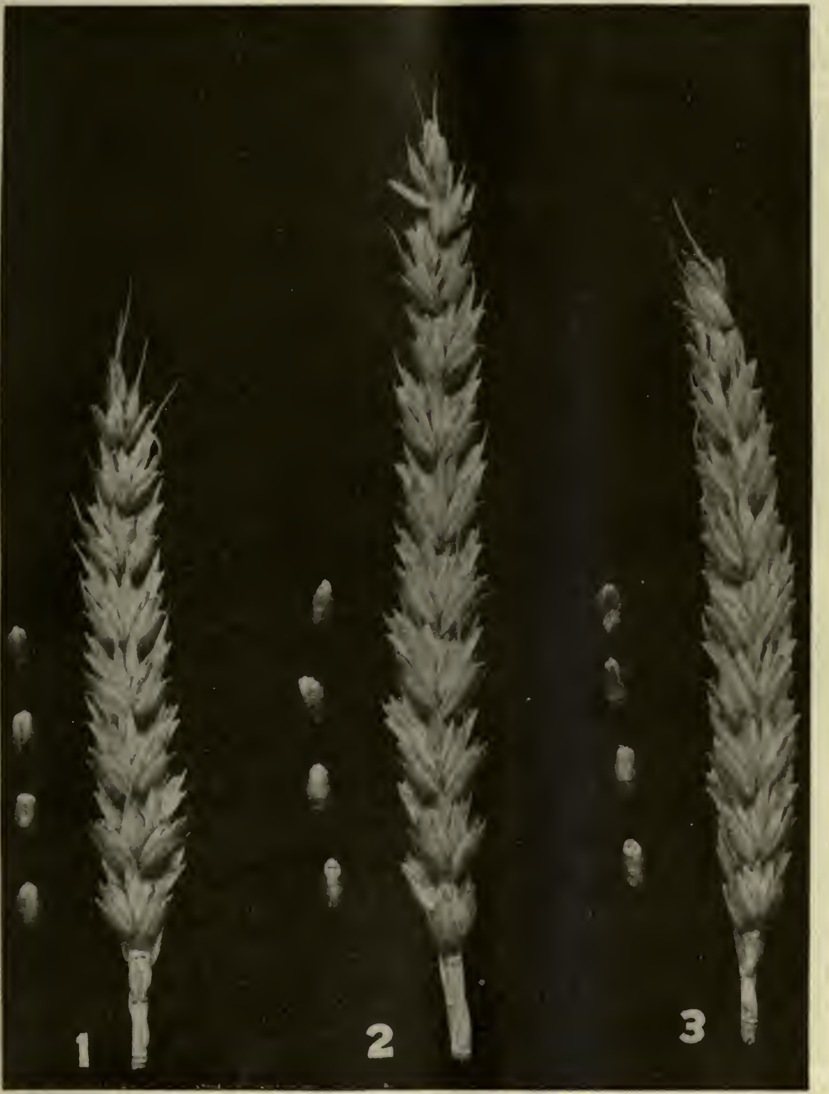

FIG. 1.—Heads and kernels of three varieties of hard spring wheat, natural size: 1, Marquis; 2, Glyndon; 3, Haynes.

MARQUIS WHEAT IN THE UNITED STATES.

A considerable quantity of seed was brought into this country from Canada for sowing in 1913. Much larger quantities were imported for sowing in 1914. This importation, with the seed home grown in 1913, was sufficient to sow about half a million acres in

1914. The resulting crop of some 7,000,000 bushels gave a large supply of seed in this country, and very little has been imported since. Most of the original seed was sold in Minnesota, North Dakota, Montana, and Washington. Smaller quantities have been sold as far south as Iowa and Nebraska.

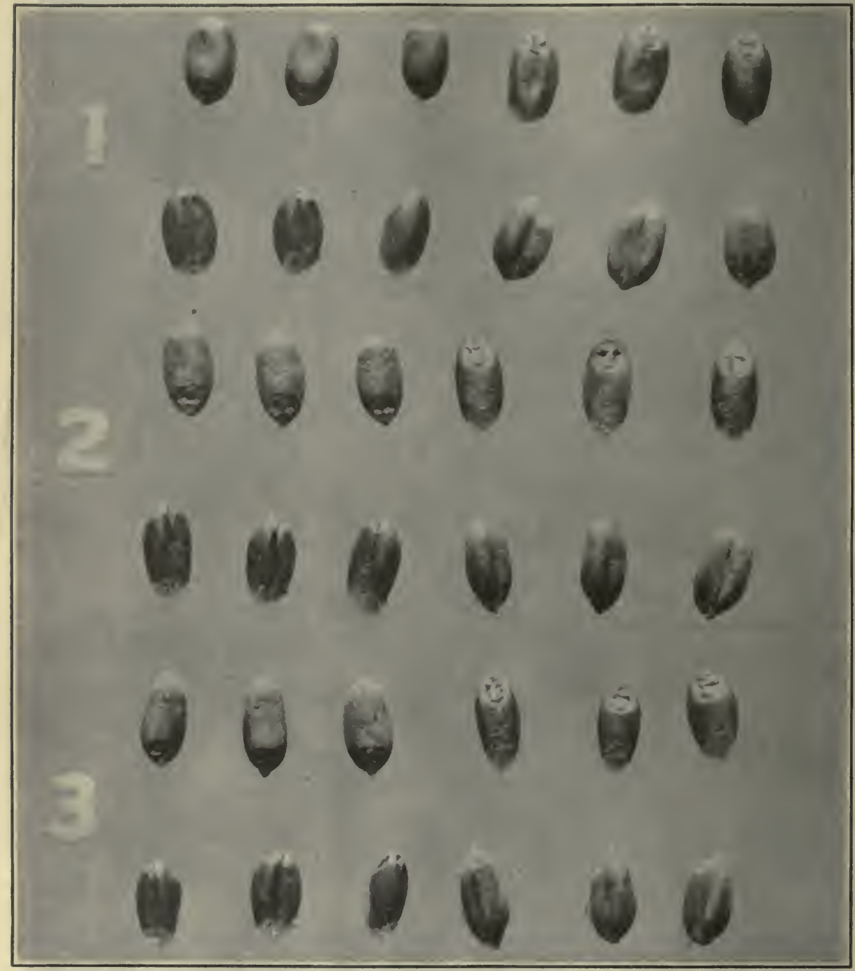

FIG. 2.—Kernels of three varieties of hard spring common wheat, twice natural size: 1, Marquis; 2, Glyndon; 3, Haynes.

As soon as Marquis wheat attracted attention, the United States Department of Agriculture and various State agricultural experiment stations began to test it for yielding power and milling value.

The experiments have covered thirteen States,[1] from Iowa and Minnesota on the east to Oregon and California on the west. In this long stretch of territory the adaptation and value of Marquis wheat vary with the local conditions.

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[1] The courtesy of the directors and other officers of the State agricultural experiment stations of Iowa, Minnesota, Nebraska, North Dakota, and California, in furnishing experimental data on Marquis wheat, is hereby gratefully acknowledged.

This portion of the United States may be separated into four divisions, according to these prevailing conditions. These divisions may be called (1) the northern Prairie or subhumid section, (2) the northern Great Plains or semiarid section, (3) the western Basin and Coast or arid areas, and (4) the irrigated districts of the northern Rocky Mountain region and Great Basin area. The Great Basin area in the third division may be separated into the Great Basin proper, the Snake River Basin, the Harney Valley, and the Columbia Basin.

VALUE IN THE SUBHUMID SECTION.

The subhumid section covers only the northern Prairie States lying west of the Mississippi River. It includes Iowa, Minnesota, and the subhumid eastern parts of Nebraska and the two Dakotas. Marquis wheat has been grown to a considerable extent in this subhumid part of the upper Mississippi Valley.

The principal spring wheats are varieties of the Fife, Bluestem, and Preston groups. Marquis wheat slightly outyields all varieties of these groups of spring wheat in this section. Where winter wheat can be grown, however, it outyields any spring wheat.

The conclusions from these facts may be stated as follows: Grow winter wheat wherever and whenever you can in this section. When spring wheat is to be grown, the Marquis is a good variety. Do not hastily discard well-known varieties of Fife, Bluestem, and Preston wheats now grown. When Marquis is tried, compare it carefully with the other spring wheats. Hold fast to that which is best.

VALUE IN THE SEMIARID SECTION.

The semiarid section covers most of the northern half of the Great Plains area. It includes, therefore, most of Nebraska and the Dakotas, northeastern Colorado, eastern Wyoming, and the eastern half of Montana.

Two classes of spring wheat, common and durum, are grown in these States. All the leading varieties of spring common wheat belong to the Fife, Bluestem, and Preston groups. Marquis has proved to be as good a yielder as any of the varieties in these groups in this section. Almost all of the durum wheat is of two varieties, Kubanka and Arnautka. Throughout this section durum wheats outyield spring common wheats, including Marquis.

Winter wheat, again, is decidedly better than any spring wheat in much of this section. In central South Dakota and central and western North Dakota, however, winter wheat can not be grown. All the winter wheat grown in this section belongs to the Crimean group of hard red winter wheat. The leading varieties are Turkey, Kharkof, Crimean, and Beloglina. Across the line in the Canadian Province of Alberta, Turkey is called Alberta Red.

The following conclusions are based on the facts given above:

(1) Winter varieties are best where they can be grown in the northern section of the Great Plains area.

(2) Durum wheats are better than any spring common wheats in this section.

(3) Marquis is better than any other variety of the spring common wheats in some parts and about as good as any in all parts of this section. Where spring wheat is grown and durum wheat is not used, the Marquis is a safe variety to grow.

It is especially well adapted to central South Dakota. Here drought and rust often reduce the yields of later maturing varieties. Preston ("Velvet Chaff"), a bearded wheat, is now the leading variety in that district. Marquis is beardless and a better yielder, as well as a better milling wheat.

Rust and drought are not so frequent in North Dakota and Montana. The earliness of Marquis gives it an advantage when they do occur. The later maturing Fife and Bluestem varieties may give as high average yields in a series of years.

VALUE IN THE ARID SECTIONS.

The dry lands of the States west of the Rocky Mountains are included in the arid sections. The different sections represented are known as the Great Basin, the Snake River Basin, the Harney Valley, the Columbia Basin, and the Sacramento Valley.

Marquis wheat has not been widely introduced in these sections. Several carloads have been sold for seed in the Columbia Basin counties of Washington.

At most places in these States good varieties of spring wheat outyield the Marquis. Palouse Bluestem, Early Baart, and sometimes even Little Club have outyielded the Marquis variety. It also is not as good as several of the new wheats which have been bred at these western stations but are not yet grown on the farms. Marquis is not recommended for any district west of the Rocky Mountains.

The hard red winter wheats of the Crimean group are now widely grown in the wheat districts of Utah, Idaho, Oregon, and Washington. Wherever these wheats are grown they outyield any variety of spring wheat.

VALUE UNDER IRRIGATION.

Irrigated farming is confined to the valleys more or less adjacent to the mountains of the Western States. Marquis wheat has not been grown to any extent under irrigation.

In western South Dakota and in Montana, Marquis has given good results, according to the limited information at hand.

In Idaho and Nevada the soft white spring wheats, like Dicklow, Defiance, Palouse Bluestem, and Little Club, all have outyielded Marquis under irrigation. Marquis wheat should not be grown under irrigation west of the Rocky Mountains, where there is a good market for these soft white wheats.

MILLING VALUE.

Marquis wheat is a first-class wheat for flour making. The Fife and Bluestem wheats are the standard hard red spring wheats for this purpose. Numerous milling tests show that Marquis is equal or slightly superior to similar samples of Fife and Bluestem wheat.

LIST OF PUBLICATIONS ON WHEATS.

BUREAU OF PLANT INDUSTRY BULLETINS.

Improvement of the Wheat Crop in California. Bulletin 178. Price, 10 cents.
Cooperative Grain Investigations at McPherson, Kans., 1904–1909. Bulletin 240. Price, 5 cents.
Cereal Experiments in the Texas Panhandle. Bulletin 283. Price, 10 cents.

BUREAU OF PLANT INDUSTRY CIRCULARS.

Dry-Land Grains for Western North and South Dakota. Circular 59. Price, 5 cents.
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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 733 JUNE 9, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE CORN AND COTTON WIREWORM[1] IN ITS RELATION TO CEREAL AND FORAGE CROPS, WITH CONTROL MEASURES.

By EDMUND H. GIBSON,

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INTRODUCTION.

During the three years which have elapsed since the investigation of the corn and cotton wireworm (fig. 1, *b*) was begun there have been constant requests by farmers and others for remedial measures, and it is in answer to these requests that the present paper has been prepared. The injury, as in the case with other wireworms, is caused by the feeding of the worm-like young or larvæ of slender beetles, known as "click beetles" or "snapping beetles," upon the roots, sprouts, and underground stems of plants which are thereby weakened and stunted or killed.

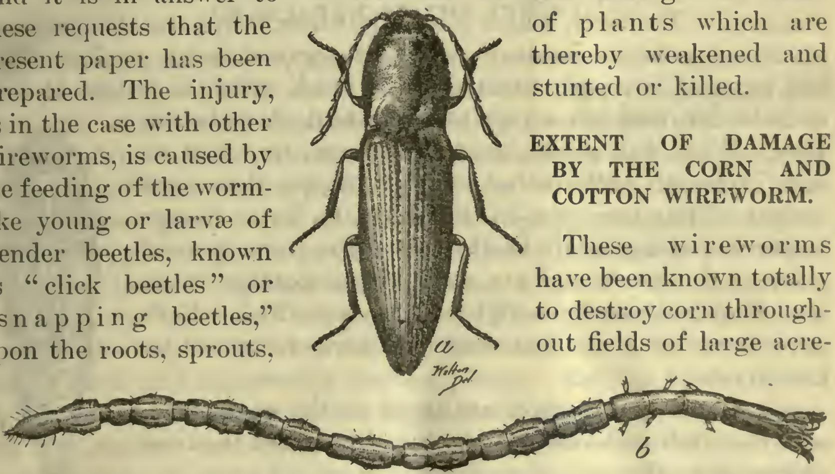

FIG. 1.—The corn and cotton wireworm: *a*, Adult, or beetle; *b*, larva, or wireworm. Much enlarged. (Hyslop.)

EXTENT OF DAMAGE BY THE CORN AND COTTON WIREWORM.

These wireworms have been known totally to destroy corn throughout fields of large acreage. However, this is not usually the case and the attack is most frequently concentrated in "spots" scattered throughout the field, the plants in these spots being wholly destroyed. In other parts of the field there may be slight injury as shown by the dwarfed ap-

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[1] *Horistonotus uhleri* Horn; order Coleoptera, family Elateridae.

NOTE.—The object of this bulletin is to set forth in a popular form what is known of the habits of the destructive corn and cotton wireworm, in order that farmers and planters may more effectively carry out control measures and be able better to handle infested areas, that the injury may be reduced to a minimum.

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pearance of the plants, which may later produce 50 per cent or more of a normal yield.

The wireworms are ravenous feeders, often cutting off all the roots of a plant. They are especially destructive during the two months before they transform to adults. A single half-grown wireworm is capable of killing a young corn sprout and severely injuring a plant from 6 to 8 inches in height. Therefore it can be seen that when there is a concentrated attack by many wireworms in one hill the plants have but small chance of surviving.

DESCRIPTION OF THE INSECT IN ITS DIFFERENT STAGES.

The parent of the corn and cotton wireworm (fig. 1, *a*) is a small dark brown click-beetle, or "snapping beetle," measuring about one-fourth of an inch in length. The eggs (fig. 2) laid by this beetle are white and nearly round; when first deposited they are translucent, but in a day or two become opaque. The young wireworms, or larvæ, after hatching from the eggs are minute, measuring from an eighth to three-sixteenths of an inch in length. When from half to full grown (fig. 1, *b*) they may be described as "soft, membranous, and elongate." The body, which is usually white, is apparently composed of 26 segments, or joints, every third segment being swollen. The last segment is simply pointed. The head, which is yellow, is long and slender, and has a pair of prominent, dark brown jaws. When full grown these larvæ measure about an inch in length and are but slightly thicker than pack thread. The pupæ (fig. 3), to which the larvæ change before becoming adult beetles, have the same general color as the larvæ and are about five-sixteenths of an inch long and nearly an eighth of an inch thick. Each pupa occurs in a small earthen chamber constructed by the larva.

FIG. 2.—Egg of the corn and cotton wireworm. Much enlarged. (Original.)

All stages of the insect are spent in the ground except the adult or beetle, which only enters it at the time of egg deposition.

There are a number of other species of wireworms which are often found associated with this wireworm about the roots of corn and others of its food plants. The corn and cotton wireworm can be easily distinguished from these, however, by its light creamy color and threadlike form, as most other wireworms are stouter and usually either reddish or brownish.

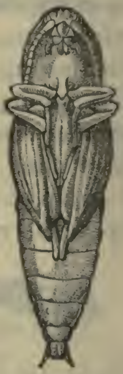

FIG. 3.—Pupa, or resting stage, of the corn and cotton wireworm. Much enlarged. (Original.)

WHERE THE INSECT OCCURS.

Reports show that the corn and cotton wireworm has been destructive in the Carolinas, Illinois, Missouri, Arkansas, and Mississippi. This would indicate a wide distribution, probably a wider one than the mere records reveal, and it is possible that the species may occur throughout the entire eastern half of the United States. Its occurrence is closely related to the distribution of soils of light sandy type, as it is known that the immature stages exist only in such soils. Occasionally an adult has been collected several miles from sandy locations, but its presence there was more than likely due to its own flight from the field of its origin. In some localities this species is referred to as the "sandy-spot wireworm."

PLANTS ATTACKED.

Cotton and corn constitute the principal food plants of this wireworm, and of the cereal and forage crops in the South the greatest damage is done each year to corn. The wireworms, besides feeding upon the roots of corn and cotton, are known to attack oats, rye, cowpeas, crab grass, and Johnson grass. Sweet potatoes, peanuts, tobacco, watermelons, and the roots of a wild bamboo are also among the food plants of this wireworm. The adults have been observed feeding on stems of cowpeas and on young, tender leaves of corn and crab grass.

CHARACTER OF THE INJURY.

Corn plants infested by this wireworm become wilted and stunted, with leaves of a bluish shade, brown at the tips, which stand out from the stalks stiffly instead of bending over gracefully as in a healthy plant. Deprived of most of the roots through the work of the larvæ of this wireworm, the plant can be pulled up with little effort. Weak plants soon succumb, leaving gaps in the rows, but the more vigorous plants put forth new roots in abnormal numbers. These are matted together and distorted, and although the plants survive, only "nubbins" are produced. The infestation is not confined to the impoverished areas, for there may be larvæ among the roots of tall and apparently healthy plants. Rolling land infested by this insect presents a patchy appearance, the sandy knolls standing out distinct and bare, although overgrown later with weeds, particularly crab grass, briers, and morning-glories. For a long time there was a theory among farmers that lightning caused the injury to corn which is now rightly attributed to this wireworm.

In the case of cowpeas, the fibrous roots suffer most, the thicker roots being perforated, so that the plants become yellow and dwarfed, and fail to vine.

Cotton is injured in the early stages by larvæ boring into the seed and injuring the very young plants, checking the growth so much that the plant dies or struggles along only to produce little or no cotton.

LIFE HISTORY OF THE SPECIES.

Beetles of the corn and cotton wireworm (fig. 1, *a*) are abroad in the fields from early June until the last of August. The eggs (fig. 2), which are laid in groups of from 3 to 20 in the soil about the roots of corn, cowpeas, and other food plants, are deposited, for the most part, during late June and July. These hatch in from 8 to 11 days into the young wireworms or larvæ (fig. 1, *b*) which immediately commence feeding upon the roots. The exact duration of the period of development in the soil has not yet been determined, but the information now at hand indicates that the species lives in the larval stage for two years and possibly three. It is true that adults are to be found each year, but this is probably due to overlapping broods. During May or June each full-grown larva constructs a small earthen cell in the soil and in this it changes to a pupa (fig. 3). The pupal stage averages 12 days in length and during this time the pupa is almost motionless and takes no food. After this it transforms to the adult or beetle. As is usually the case, the duration of the egg and pupal stages varies with temperature and moisture conditions.

HABITS OF THE LARVÆ, OR WIREWORMS.

The larvæ, or wireworms, feed upon the roots of their food plants throughout the summer months and up to about the first of October, and during this time are found within 18 inches of the surface of the ground, the depth depending upon the moisture content of the top soil. During a hot, dry spell the wireworms remain from 12 to 18 inches below the surface, but after a rain they can be found within 2 inches of the surface.

With the approach of cold weather they begin a general downward movement, which accounts for the farmer's inability to locate them during the late fall and winter months. At Charleston, Mo., December 1, 1914, they were found in the sand at the remarkable depth of 5 feet. This appeared to be the average depth at which they remained during the winter in this locality, observations showing the depth to vary from 4 to 6 feet. From these facts it will be seen that fall or winter plowing would be useless as a control or remedial measure.

By the last of February in some localities, or as soon as winter breaks up, the larvæ gradually make their way to within 2 to 3 feet of the surface. By the middle of April they are numerous within 6 inches of the surface of the ground. From the time the larvæ travel downward in the fall until they return to the top soil they eat practically nothing. In laboratory experiments, larvæ remained alive and healthy in cages of moist pure sand, without organic food, for six months.

The larvæ are quick of movement and wriggle vigorously when disturbed. In indoor rearing cages they are found to be keenly susceptible to an overabundance of moisture, and, too, will die if the cage soil is allowed to get excessively dry.

Cannibalism is common among them, especially under artificial rearing conditions, but the fact that as many as 106 larvæ have been found in one hill of corn is evidence that this habit does not exist to any great extent in the field when there is plenty of plant food at hand.

HABITS OF THE ADULTS, OR BEETLES.

The adults, or beetles, are also very quick of movement. Immediately upon being disturbed they "snap" themselves and fall to the ground from the leaf or stem upon which they are resting. On the ground they feign death for a few moments, then quickly scamper off to a hiding place. The adults feed very little, hence any injury which they might cause would be hardly perceptible.

They evidently fly well, as they have been collected in quantities around lights at night. This would probably explain the fact that adults have been collected several miles from the nearest sandy spot or field. The author, however, has never seen them fly in the daytime.

The female beetles will not deposit eggs in soil which is crusted over or baked, but leave such a field and search for one which is covered by a dust mulch, or which has recently been plowed. This fact is important and should be taken into account when control measures are being considered, since cultivation at the time the beetles are most numerous means that excellent conditions are given the females for depositing their eggs.

NATURAL ENEMIES.

Comparatively few natural enemies of this wireworm have been noted. No internal parasites have been reared from any stage of the species. Birds feed upon all kinds of wireworms, including those of the genus Horistonotus.

INEFFECTUAL REMEDIAL MEASURES.

PLOWING.

Late fall and winter plowing as a method of reducing the numbers of the pest by turning up and exposing the larvæ to the elements is of no value, as the wireworms are at this time at such depths in the soil that they would not be disturbed by the plowing. Plowing or cultivating for this purpose at other times of the year is of little avail as the wireworms are so quick of movement that almost as soon as exposed they are again hidden in the loosened soil. Even chickens or turkeys are not sufficiently alert to catch many.

TRAPPING ADULT BEETLES.

Trapping the beetles at night by means of strong lights above open vessels containing water or kerosene would in no way prove practical, especially on a large scale.

POISONING.

Killing the wireworms by placing poisoned baits in the soil around the hills of corn is not practical, nor will the treating of seeds with poisons or repellents assist in protecting the plants from wireworm attacks. Turning under wood ashes, as a remedy against wireworms, has proved to be of no avail.

EFFECTIVE CONTROL AND REMEDIAL MEASURES.

The following control measures are formulated from the study of the habits of the insect, and are based on results of such measures carried on over a period of two years. It must be remembered that as this species has been under investigation for only three years, the following remedial measures are subject to more or less modification.

HASTENING EARLY PLANT GROWTH.

The most important factor in reducing injury by this wireworm is the employment of methods which hasten early plant growth in the spring, the object of stimulating growth being to enable the plants the better to withstand the attacks of the wireworms. In the case of corn this consists of early planting—at least by April 20 for southeastern Missouri and northeastern Arkansas—followed by frequent cultivation until the middle of June.

CROP ROTATION.

Any system of crop rotation after harvesting the corn may be carried out, and a winter cover crop such as wheat or rye is advised. Pasturing this during winter months and turning it under in the spring is very beneficial, since humus is thus added and the sandy soil is thereby stiffened. An infested field should not be planted to corn two years in succession.

If a catch crop of red clover can be obtained it is an excellent one to come in the rotation for two or three years. Such combinations as wheat and clover are to be recommended for southeastern Missouri, as they not only afford two crops a year from the same field, but also permit the soil to remain undisturbed during the period when the female beetles are laying their eggs. As stated elsewhere in this bulletin, the females prefer loose soil for egg deposition, especially soil which has been recently cultivated or plowed.

A system of handling the ground and crops so that the soil will not be disturbed from the middle of June until the middle of August is one of great importance, and it may prove to be the most beneficial step in eradicating the wireworms from an infested area. This may be brought about by omitting from the rotation such crops as would normally require summer cultivation.

The supposition that an infestation of the corn and cotton wireworm is worse following cowpeas seems to be unfounded.

MANURING.

The manuring of infested areas has long been recommended as the best control measure. The theory was advanced, especially by some farmers, that the manure turned under is actually distasteful to the larvæ and kills them outright. Although this is not the case, nevertheless the turning under of manure and cover crops has the effect of adding humus to the top soil; and, as it is known that the larvæ can not long survive except in sandy soils, it is well to spread as much manure as possible on infested areas and to turn it under.

LAND RESTING.

If it were practicable to allow the infested fields to lie idle, or "lay out," as it is termed, for a period of three years, this would no doubt prove the most effective means of getting rid of the pest, since by leaving the ground undisturbed a crust would be formed on the surface through which the majority of adult wireworms could not emerge. It would also serve to prevent the few emerging adults, as well as those flying in from other fields, from entering the soil for egg deposition. However, this practice naturally will not often appeal to the farmer.

SUMMARY OF CONTROL MEASURES.

(1) Plant infested fields to such crops as do not require summer cultivation, such as clover, cowpeas, soy beans, or grasses.

(2) Add humus to the light sandy spots by turning under manure and cover crops.

(3) If grain crops be planted, allow stubble to remain until the middle of August.

(4) If corn must be grown, plant early and do everything possible to hasten rapid growth. Do not plant corn two years in succession.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS.

AVAILABLE FOR FREE DISTRIBUTION.

Cotton Bollworm. (Farmers' Bulletin 290.)
Common White Grubs. (Farmers' Bulletin 543.)
The Chalcis-fly in Alfalfa Seed. (Farmers' Bulletin 636.)
The Grasshopper Problem and Alfalfa Culture. (Farmers' Bulletin 637.)
The Hessian Fly. (Farmers' Bulletin 640.)
Alfalfa Attacked by the Clover-root Curculio. (Farmers' Bulletin 649.)
The Chinch Bug. (Farmers' Bulletin 657.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
The True Army Worm and its Control. (Farmers' Bulletin 731.)
The Hessian Fly Situation in 1915. (Office of Secretary Circular 51.)
The Spring Grain Aphis or "Green Bug" in the Southwest and the Possibilities of an Outbreak in 1916. (Office of the Secretary Circular 55.)
Southern Corn Rootworm, or Budworm. (Department Bulletin 5.)
Western Corn Rootworm. (Department Bulletin 8.)
The Oat Aphis. (Department Bulletin 112.)
The Alfalfa Caterpillar. (Department Bulletin 124.)
Clover Mite. (Entomology Circular 158.)
Clover-root Curculio. (Entomology Bulletin 85, pt. III.)
Maize Billbug. (Entomology Bulletin 95, pt. II.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

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The Southern Corn Leaf-Beetle. (Department Bulletin 221.) Price, 5 cents.
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Spring Grain-aphis or Green Bug. (Entomology Bulletin 110.) Price, 25 cents.
Preliminary Report on Alfalfa Weevil. (Entomology Bulletin 112.) Price, 15 cents.

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FLYTRAPS AND THEIR OPERATION.

By F. C. BISHOPP, *Entomological Assistant.*

INTRODUCTION.

Flytraps have a distinct place in the control of the house fly and other noxious fly species. There is a general tendency, however, for those engaged in combating flies to put too much dependence on the flytrap as a method of abating the nuisance. It should be borne in mind that flytrapping is only supplementary to other methods of control, most notable of which is the prevention of breeding either by completely disposing of breeding places or by treating the breeding material with chemicals.[1]

It may be said that there are two main ways in which flytraps are valuable: (1) Catching flies which come to clean premises from other places which are insanitary and (2) capturing those flies which invariably escape in greater or less numbers the other means of destruction which may be practiced. Furthermore, the number of flies caught in traps serves as an index of the effectiveness of campaigns against breeding places.

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[1] Results obtained in experiments with the use of chemicals against fly larvæ in manure are presented in Bulletins Nos. 118 and 245 of the Department of Agriculture. The biology of the house fly and the various methods of control are discussed in Farmers' Bulletin 679.

NOTE.—This bulletin is intended to give directions for the use of a supplementary means of controlling flies; it is adapted to all parts of the United States.

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Fly trapping should begin early in spring if it is to be of greatest value. Although comparatively few flies are caught in the early spring, their destruction means *the prevention of the development of myriads of flies by midsummer.*

KINDS OF FLIES CAUGHT.

The various species of flies which are commonly annoying about habitations or where foodstuffs are being prepared may be divided roughly into two classes: (1) Those which breed in animal matter, consisting mainly of the so-called "blowflies"; and (2) those which breed in vegetable as well as in animal matter. In the latter group the house fly is by far the most important. The stable fly is strictly a vegetable breeder, as are also certain other species which occasionally come into houses and may in rare cases contaminate foodstuffs. The stable fly, which breeds in manure or decaying vegetable matter, and the horn fly, which breeds in cow manure, are bloodsucking species, and can be caught in ordinary flytraps in comparatively small numbers only. The kind of flies caught depends to a considerable extent on the material used for bait. In general the house fly and other species which breed in vegetable matter are attracted to vegetable substances, while the blowflies will come most readily to animal matter. This rule, of course, is not absolute, as flies are less restricted in feeding than in breeding habits, and, as is well known, the house fly is attracted to a greater or less extent to any moist material, especially if it has an odor.

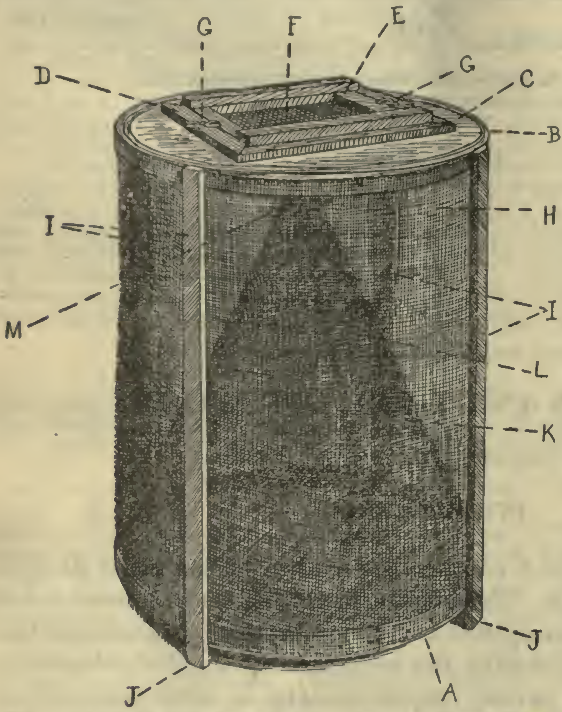

FIG. 1.—Conical hoop flytrap; side view. *A*, Hoops forming frame at bottom. *B*, Hoops forming frame at top. *C*, Top of trap made of barrel head. *D*, Strips around door. *E*, Door frame. *F*, Screen on door. *G*, Buttons holding door. *H*, Screen on outside of trap. *I*, Strips on side of trap between hoops. *J*, Tips of these strips projecting to form legs. *K*, Cone. *L*, United edges of screen forming cone. *M*, Aperture at apex of cone. (Author's illustration.)

TYPES OF TRAPS.

The same general principle is involved in nearly all flytraps in use, though superficially they may appear quite different. The flies are attracted into a cage, as it were, by going through a passage the entrance of which is large and the exit small, so there is little chance of the flies, once in, finding their way out again. This principle is modified to fit different conditions. For instance, the window trap, devised by Prof. C. F. Hodge, catches the flies as they endeavor to enter or leave a building; the garbage-can trap, for which Prof. Hodge is also to be credited, catches the flies that have entered garbage cans; and the manure-box trap retains the flies bred from infested manure put into the box.

The attractant used to induce flies to enter traps may consist of (1) food, as in baited traps; (2) odors, as in window traps placed in windows from which odors are emitted; and (3) light, as in traps on manure boxes. Of course light is an important factor in the success of all traps, for, as is well known, flies have a marked tendency to go toward the light, and they usually enter the trap by flying toward the light after having been attracted beneath it by bait or after entering a room in search of food.

CONICAL TRAPS.

A number of traps of this general type are on the market, but most of these are of small size. Nearly all are constructed with a dome instead of a cone, and on this account the catching power is reduced about one-third. Moreover, the farmer, dairyman, or anyone with a few tools can construct traps at a small fraction of the sale price of ready-made ones.

THE CONICAL HOOP TRAP.

A trap which appears from extensive tests made by Mr. E. W. Laake and the author to be best for effective trapping, durability, ease of construction and repair, and cheapness may be made as follows:

The trap consists essentially of a screen cylinder with a frame made of barrel hoops, in the bottom of which is inserted a screen cone. The height of the cylinder is 24 inches, the diameter 18 inches, and the cone is 22 inches high, and 18 inches in diameter at the base. Material necessary for this trap consists of four new or secondhand wooden barrel hoops, one barrel head, four laths, 10 feet of strips 1 to 1½ inches wide by one-half inch thick (portions of old boxes will suffice), 61 linear inches of 12 or 14 mesh galvanized screening 24 inches wide for the sides of the trap and 41 inches of screening 26 inches wide for the cone and door, an ounce of carpet tacks, and two turn-buttons, which may be made of wood. The total cost of the material for this trap, if all is bought new at retail prices, is about 65 cents. In practically all cases, however, the barrel hoops, barrel head, lath, and strips can be obtained without expense. This would reduce the cost to that of the wire and tacks, which would be 45 cents. If a larger number of traps are constructed at one time the cost is considerably reduced.

One of these traps is illustrated in figures 1 and 2. In constructing the trap two of the hoops are bent in a circle (18 inches in diameter on the inside), and nailed together, the ends being trimmed to give a close fit. These form the bottom of the frame (*A*), and the other two, prepared in a similar way, the top (*B*). The top (*C*) of the trap is made of an ordinary barrel head with the bevel edge sawed off sufficiently to cause the head to fit closely in the hoops and allow secure nailing. A square, 10 inches on the side, is cut out of the center of the top to form a door. The portions of the top (barrel head) are held together by inch strips (*D*) placed around the opening one-half inch from the edge to form a jamb for the door. The door consists of a narrow frame (*E*) covered with screen (*F*) well fitted to the trap and held in place (not hinged) by buttons (*G*). The top is then nailed in the upper hoops and the sides (*H*) formed by closely tacking screen wire on the outside of the hoops. Four laths (*I*) (or light strips) are nailed to the hoops on the outside of the trap to act as supports between the hoops, and the ends are allowed to pro-

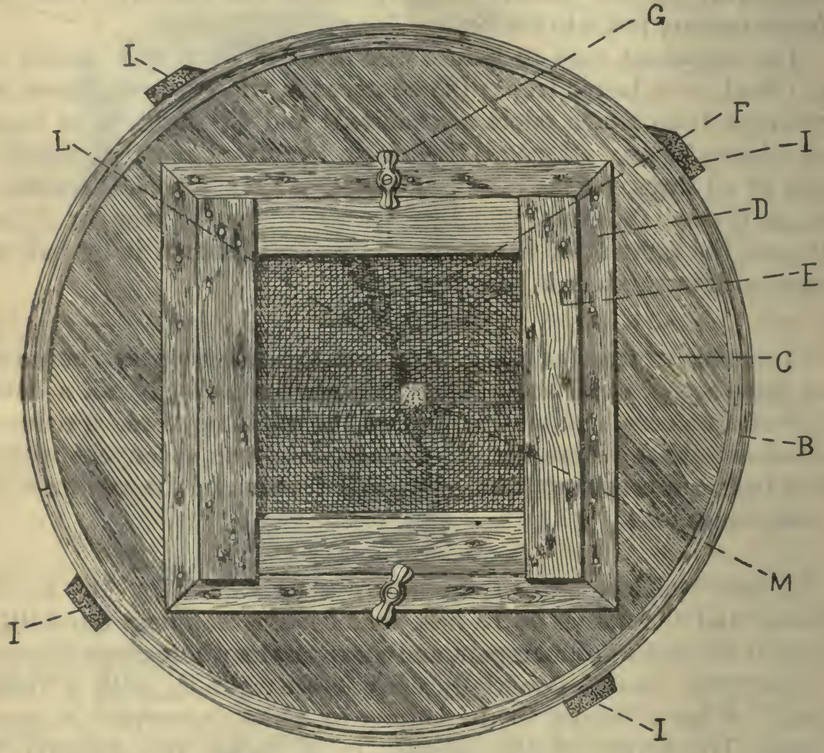

FIG. 2.—Conical hoop flytrap; top view. Letters designate parts as in figure 1. (Author's illustration.)

ject 1 inch at the bottom to form legs (*J*). The cone (*K*) is cut from the screen and either sewed with fine wire or soldered where the edges meet at (*L*). The apex of the cone is then cut off to give an aperture (*M*) 1 inch in diameter. It is then inserted in the trap and closely tacked to the hoop around the base.

The construction of a cone of any given height or diameter is quite simple if the following method be observed. It is best to cut a pattern from a large piece of heavy paper, cardboard, or tin. Figure 3 illustrates the method of laying out a cone of the proper dimensions for the above trap. An ordinary square is placed on the material from which the pattern is to be cut; a distance (22 inches) equal to the height of the cone is laid off on one leg of the square at *A*, and a distance (9 inches) equal to one-half of the diameter of the base of the cone is laid off on the other leg at *B*, and a line is drawn between the points *A* and *B*. With the distance between these points as a radius and with the point *A* as a center, the portion of a circle *C D*, is drawn. With a pair of dividers, the legs of which are set 1 inch apart, or with the square, lay off as many inches on the arc *C D*, starting at *C*, as there are inches around the base of the cone, which in this case is about 56½ inches, reaching nearly to the point *E*. Then add one-half inch for the lapping of the edges of the cone, and one-half inch which is taken up when the cone is tacked in, thus making a total distance from *C* to *E* of 57½ inches. Draw a line from *A* to *C* and another from *A* to *E*, and cut out the pattern on these lines and on the arc from *C* to *E*, as shown in figure 3. The edges *AC* and *AE* are then brought together, lapped one-half inch and sewed with wire or soldered. After the aperture

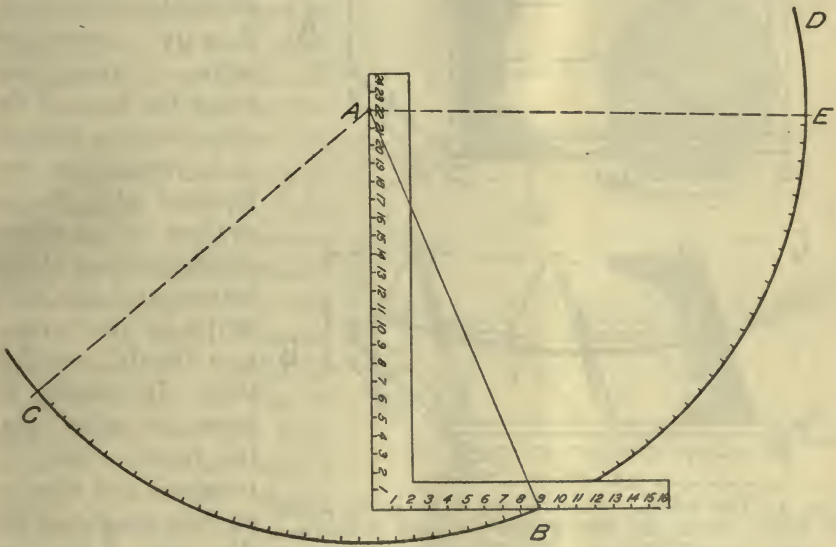

FIG. 3.—Method of laying out a pattern for the construction of a cone. Cut out on curved line *C* to *E* and on dotted lines from *A* to *C* and *A* to *E*. (Author's illustration.)

of the cone is formed by cutting off the apex, as previously described, it is ready for insertion in the trap.

In order to figure the distance around the base of a cone of any given diameter, multiply the diameter by 3.1416 or 3⅐.

The height of the legs of the trap, the height of the cone, and the size of the aperture in the top of the cone, each are of importance in securing the greatest efficiency.

OTHER FORMS OF CONICAL TRAPS.

Conical traps with steel frames are satisfactory, but they are less easily rescreened and it is more difficult to keep the lids closely fitted. These, of course, can be constructed only by shops with considerable equipment. Traps constructed with a wooden disk about the base of the cone, and a similar disk around the top to serve as a frame, or those with a square wooden frame at the bottom and top with strips up the corners are fairly satisfactory. It should be borne in mind that the factor which determines the number of flies caught is the diameter of the base of the cone, if other things are equal. Therefore the space taken up by the wooden framework is largely wasted, and if it is too wide it will have a deterrent effect on the flies which come toward the bait. For this reason it is advisable that the wood around the base of the cone should be as narrow as consistent with strength—usually about 3 inches.

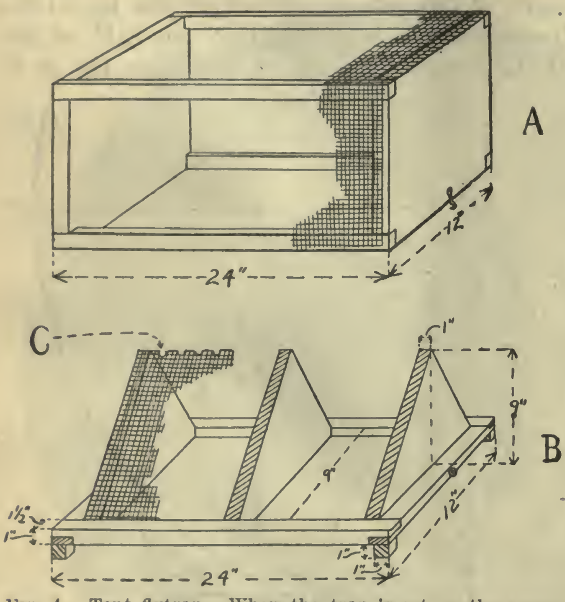

FIG. 4.—Tent flytrap. When the trap is set up the screen box, *A*, fits on the base, *B*, and two pans of bait are placed beneath the tent. *C*, Hole in screen at apex of tent. (Original.)

Under no condition should the sides or top of the trap be of solid material, as the elimination of light from the top or sides has been found to decrease the catch from 50 to 75 per cent.

TENT TRAPS.

The tent form of trap has been widely advocated in this country, but recent experiments indicate that it is much less efficient than the cone trap, and usually as difficult to construct and almost as expensive. The size of these traps may vary considerably, but one constructed according to the dimensions given in figure 4 will be found most convenient. The height of the tent should be about equal to the width of the base, and the holes (*C*) along the apex of the tent should be one-half to three-fourths of an inch in diameter and 1 inch apart. The box (*A*) should be provided with hooks to pass through eyes on the base (*B*). Small blocks 1 inch thick are nailed beneath the corners of the tent frame to serve as legs.

GARBAGE-CAN TRAPS.

As previously mentioned, Prof. Hodge has adapted the cone trap to use on the lids of garbage cans. It is not advisable to use this trap except where garbage cans are sufficiently open to admit flies. In such cases a hole may be cut in the lid of the can and one of the small balloon traps which are obtainable on the market attached over the hole. To make the trap effective the edges of this lid should extend well down over the top of the can. The lid should be held up slightly so as to allow the flies to pass under, but not high enough to admit direct light. Practically speaking, the garbage forms the bait for this trap, and when inside the can the flies are attracted to the light admitted through the trap. It is really advisable to have the garbage cans fly proof, so as to prevent danger of fly breeding within them rather than to depend on traps on the lids, which necessarily allow odors to escape. A garbage can with a trap attached is illustrated in figure 5.

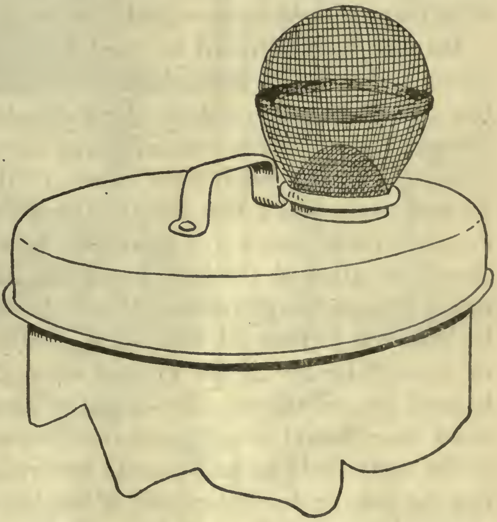

FIG. 5.—Top of garbage can with small balloon flytrap attached. (Original.)

MANURE-BOX TRAPS.

Manure pits or boxes are desirable for the temporary storage of manure, especially in towns and cities. These have been widely advocated, but the difficulty has been that manure often becomes infested before it is put into them, and flies frequently breed out before the boxes are emptied and often escape through the cracks. To obviate these difficulties a manure box or pit, with a modified tent trap or cone trap attached, is desirable. Mr. Arthur Swaim, of Florida, has devised a form of manure trap consisting of a series of screen tents with exit holes along the ridges of these, over which is a screen box. The latter retains the flies as they pass through the holes in the tents. The entire trap is removable.

In order to retain the fertilizing value of manure to the greatest extent it is advisable to exclude the air from it as much as possible and to protect it from the leaching action of rains. This being the case, there is really no necessity for covering a large portion of the top of the box with a trap, but merely to have holes large enough to attract flies to the light, and cover these holes with ordinary conical traps, with the legs cut off, so the bottom of the trap will fit closely to the box. The same arrangement can be made where manure is kept in a pit. In large bins two or more holes covered with traps should be provided for the escape of the flies.

Manure boxes should be used by all stock owners in towns and cities, and they are also adaptable to farms. The size of the manure bin should be governed by the individual needs, but for use on the farm it is desirable to make it large enough to hold all of the manure produced during the busiest season of the year. A box 14 feet long, 10 feet wide, and 4 feet deep will hold the manure produced by two horses during about five months. About 2 cubic feet of box space should be allowed for each horse per day. The bin should be made of concrete or heavy plank. When the latter is used the cracks should be battened to prevent the escape of flies. The bin may have a floor or it may be set in the ground several inches and the dirt closely banked around the outside. For the admission of the manure a good-sized door should be provided in either end of a large bin. A portion of the top should be made easily removable for convenience in emptying the box, or one entire end of the box may be hinged. On account of the danger of the door being left open through carelessness, it is advisable to arrange a lift door which can be opened by placing the foot on a treadle as the manure is shoveled in. The door should be heavy enough to close automatically when the treadle is released. A manure bin with flytrap attached is shown in figure 6.

Attention is directed to a maggot trap devised by Mr. R. H. Hutchison, as described in Bulletin No. 200 of the Department of Agriculture. Where large quantities of manure are produced on a farm this method of storing the manure on a platform and trapping the maggots which breed out may be more convenient than the manure bin.

WINDOW TRAPS.

Prof. C. F. Hodge has designed a trap which is really a modified tent trap adapted to use in a window. This trap is constructed so as to catch the flies as they enter or leave through the window. It is adaptable to barns which are fairly free from cracks or other places where flies may enter. It may also be used on windows of buildings where foodstuffs are prepared and where flies endeavor to enter through the windows or escape after having gained entrance through other passageways. All openings not provided with traps should be closely screened, and on large buildings traps may be installed in every third window.

This trap is essentially a screen box closely fitted to the frame of a window (see fig. 7). The thickness of the box at *A* should be about 12 inches. Instead of the screen running straight down over the box on either side it is folded inward nearly to the center of the frame in V-shaped folds running longitudinally across the window. One, two, or even more folds may be made in the screen on either side. The upper side of the fold *B* should extend toward the center almost at right angles with the side of the trap, that is, parallel with the top and bottom; and the lower side *C* should slant downward as shown in the drawing. The sides of the frame may be cut out at the proper angle and the pieces *D* returned after the screen has been tacked along the edges. Along the apex (inner edge) of each fold is

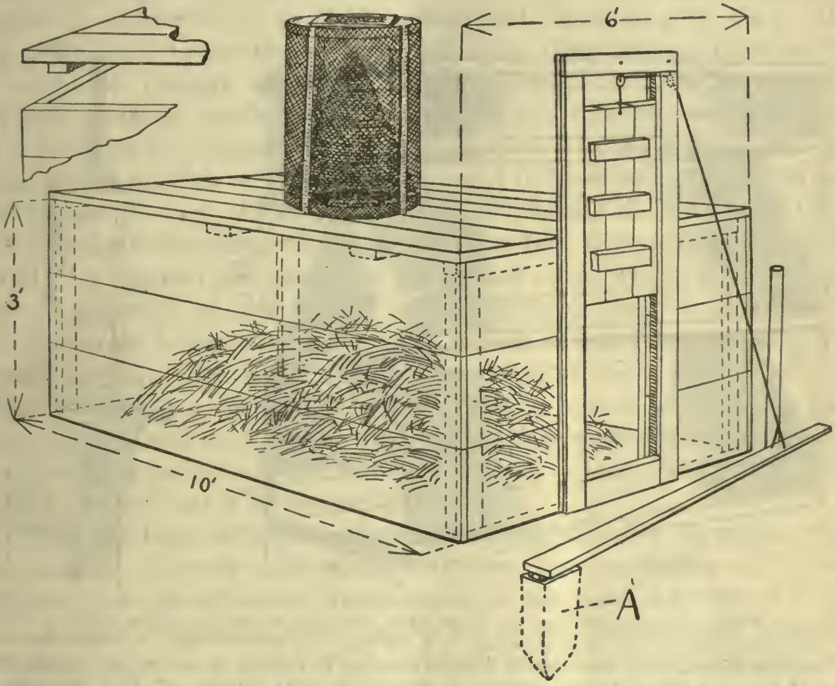

FIG. 6.—Use of flytrap in connection with manure bin. *A*, Block of wood set in ground to which lever raising door is hinged. (Original.)

punched a series of holes *E* about one-half inch in diameter and 1 inch apart. The apices of the folds on either side of the window should not be directly opposite. A narrow door *F* opening downward on hinges should be made on one side of the trap at the bottom for removal of the dead flies. The entire trap is fastened to the window by hooks so that it may be readily taken off. An additional trapping feature may be added by providing a tent trap fitted in the bottom of the box. A narrow slit is left along the base to allow the flies to enter beneath the tent. Bait may be placed under the tent to attract the flies.

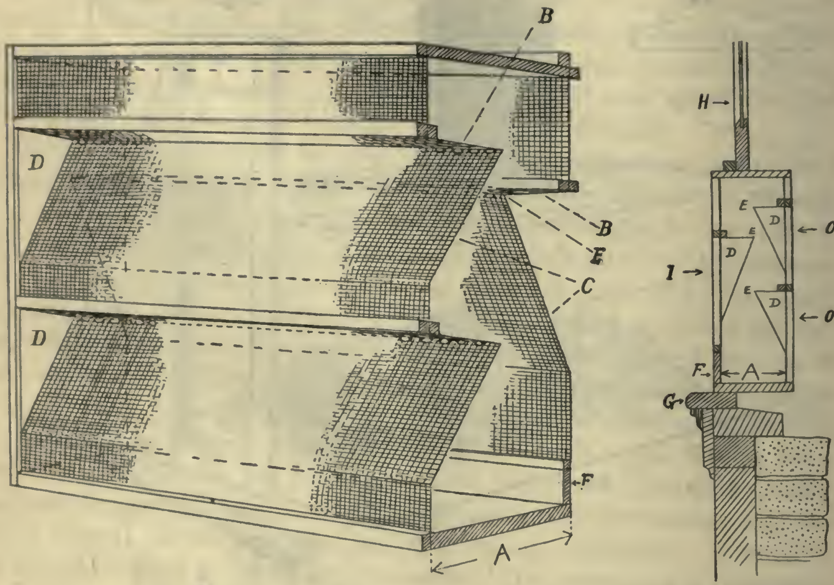

FIG. 7.—Hodge type window trap. At left, trap with end removed to show construction; at right, cross section of trap placed in a window. *A*, End of trap. *B*, Upper side of folds in screen. *C*, Lower side of folds in screen. *D*, Portion of end of trap sawed out and returned after attaching screen. *E*, Holes along apex of folds. *F*, Door for removing dead flies. *G*, Window sill. *H*, Upper window sash. *I*, Inside entrance for flies. *O*, Outside entrances. (Author's illustration.)

It has been found that the use of these window traps will aid in protecting animals in barns from stable flies and mosquitoes, and in some cases horseflies and other noxious species are caught.

BAITS FOR TRAPS.

The question of selecting the best bait for flies is an important one. As has been indicated, the kind of bait used should be governed by the species of flies which it is desired to destroy. For the most part it is the house fly which it is desired to catch, and for this insect waste beer is preeminently the best bait. In some cases it can be procured without charge and in others it is sold at from 5 to 10 cents per gallon. On dairy farms, probably milk is the next best bait, considering its convenience. The tests indicate that milk is not more than one-third as effective as beer and rather less so than a mixture of cheap molasses and water. This mixture is prepared by adding 3 parts of water to 1 part of "black-strap" molasses and allowing it to ferment for a day or two. All baits, milk, beer, etc., are much more attractive during active fermentation. Sirup made by dissolving 1 part of ordinary brown sugar in 4 parts of water and allowing the mixture to stand a day or two to induce fermentation is almost equal to the molasses and water as a fly bait. If it is desirable to use the sirup immediately after making it, a small amount of vinegar should be added. Honey bees are sometimes caught in large numbers at this bait. When this happens some of the other baits recommended should be used. In the experiments it was found possible to secure catches equal to those obtained by using stale beer through the employment of homemade malt extract; this is slightly troublesome to make and therefore does not recommend itself for general use except in towns and cities where flytraps are being operated by individuals who give much time to this work. This extract is prepared by using 1 gallon of water to 2 pounds of ground malt. The latter may be purchased at about $1 per bushel and ground in a coffee mill. The water is heated to 135° F., the malt added, and then during a period of 45 minutes the temperature is gradually raised to 160° F. The extract is then strained off the grain, cooled, and is ready for use.

With the baits before mentioned comparatively few blowflies will be caught. For use about slaughterhouses, butcher shops, and other places where blowflies are troublesome, it has been determined that the mucous membrane from the lining of the intestines of hogs is without equal as a bait. This material, which is commonly spoken of as "gut slime," can be obtained from packing houses where sausage casings are prepared. The offensive odor of this bait renders its use undesirable near materials intended for human consumption. Another packing-house product known as blood tankage is a good fly bait when used with beer. This combination results in the capture of a large percentage of house flies. Still better results are obtainable by using "gut slime" in combination with beer. Where these materials are not obtainable fairly good catches will result from the use of fish scraps or meat scraps. With any of these baits the catches will be found not to be entirely meat-infesting flies, as actual counts have shown that the precentage of house flies in traps over such baits ranges from 45 to 75.

Overripe or fermenting fruit, such as bananas, crushed and placed in the bait pans sometimes gives satisfactory results. A combination of overripe bananas with milk is much more attractive than either one used separately. A considerable number of blow-flies as well as house flies are attracted to such baits.

BAIT CONTAINERS.

The size of the bait container in relation to the size of the trap is a very important consideration. It has been found that a small pan or deep pan of bait set in the center under a trap will catch only a small fraction of the number of flies secured by using larger, shallow containers. The best and most convenient pan for baits is a shallow circular tin, such as the cover of a lard bucket. Its diameter should be about 4 inches less than that of the base of the trap, thus bringing the edge within 2 inches of the outside edge of the trap. The catch can be increased slightly by placing a piece of sponge or a few chips in the center of the bait pan to provide additional surface upon which the flies may alight. The same kind of pans for bait may be used under tent traps. Two or more pans should be used, according to the length of the trap.

CARE AND LOCATION OF TRAPS.

In many cases fly trapping has been rendered ineffectual by the fact that the traps were not properly cared for. In setting traps a location should be chosen where flies naturally congregate. This is usually on the sunny side of a building out of the wind. It is exceedingly important that the bait containers be kept well filled. This usually requires attention every other day. The bait pans should be washed out at rather frequent intervals. This gives a larger catch and avoids the danger of flies breeding in the material used for bait. Further, it should be borne in mind that traps can not be operated successfully throughout the season without emptying them. Where flies are abundant and the bait pans are properly attended to the traps should be emptied at weekly intervals. Where flies become piled high against the side of the cone the catching power of the trap is considerably reduced. The destruction of the flies is best accomplished by immersing the trap in hot water, or still better, where a tight barrel is at hand place a few live coals in a pan on the ground, scatter two tablespoonfuls of sulphur over them, place the trap over the coals, and turn the barrel over the trap. All of the flies will be rendered motionless in about five minutes. They may then be killed by using hot water, throwing them into a fire, or burying them.

STICKY FLY PAPERS.

Sticky fly papers are of some value in destroying flies which have gained access to houses, but they have marked limitations and numerous objectionable features. For use out of doors, traps are much more effective and economical.

Dr. Crumbine, of the Kansas State Board of Health, gives the following method for preparing fly paper:

"Take 2 pounds of rosin and 1 pint of castor oil, heat together until it looks like molasses. Take an ordinary paint brush and smear while hot on any kind of paper—an old newspaper is good—and place several about the room. A dozen of these may be made at a cost of 1 cent."

POISONED BAITS.

The question of destruction of flies with poisons is somewhat out of place here, but the close relationship of poisoned baits to trapping warrants a brief statement.

Probably the best poisoned bait for house flies is formaldehyde in milk used at the rate of about two tablespoonfuls of formaldehyde to a pint of a mixture of equal parts of milk and water. This is placed in flat dishes in places frequented by flies. A piece of bread or a sponge in the dish adds to the effectiveness. Stale beer or molasses and water with 8 per cent formaldehyde added will probably also give satisfactory results. As far as possible other liquids should be removed when poisoned baits are exposed.

CAUTION.

It should be borne in mind that formaldehyde, 40 per cent, is poison about in the same proportion as wood alcohol, if taken internally. It should not be inhaled, nor should the eyes be unduly exposed to it. Special pains should be taken to prevent children from drinking poisoned baits and to prevent the poisoned flies from dropping into foods or drinks.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 735 JUNE 12, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE RED SPIDER[1] ON COTTON AND HOW TO CONTROL IT.

By E. A. McGregor,

Entomological Assistant, Southern Field Crop Insect Investigations.

INTRODUCTION.

By the adoption of the preventive measures described in this bulletin it is possible to avoid the losses caused by the so-called red spider (fig. 1), a minute creature which seriously injured 20,000 acres of cotton in South Carolina in 1912, and is similarly destructive in other Southern States. Injury by the red spider in cotton fields may occur from the middle of June until the middle of September. It consists in a rusting and dropping of the leaves and sometimes in the death of the affected plants over considerable portions of the fields. For many years this trouble has been called "rust" by cotton planters, who concluded from the reddening of the leaves that it was a disease. The injury, however, is caused by the presence on the cotton leaves of multitudes of small mites called "red spiders."

GENERAL APPEARANCE AND NATURE OF DAMAGE.

The presence of the pest is first revealed by the appearance on the upper surface of the leaf of a blood-red spot. As leaves become more infested they redden or turn rusty yellow over the entire surface, become folded, then turn brown and dry, and finally drop. The lower leaves usually are first attacked, but infestation spreads upward until often only the bare stalk and one or two terminal leaves remain. (See figs. 2, 3, and 4.) Such plants almost always die.

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[1] *Tetranychus telarius* L., generally known as *T. bimaculatus* Harvey, and in some publications as *T. gloveri* Bks.; order Acarina, family Tetranychidae.

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In severe cases the dropping of the leaves is sufficient to prevent the development of lint. The loss of foliage, however, is always accompanied by the shedding of bolls, which may amount to the total loss of fruit or merely of the younger bolls. On the plants other than cotton, which the red spider often attacks, the appearance of the injury is similar to that on cotton, although it is unusual for most plants to show the red blotching. The feeding is done by means of sharp, slender, lance-like mouth parts which are thrust well into the leaf, usually on the under surface.

Injury results from the extraction by the red spiders of the juices of the plant leaves. It is plain, therefore, that the mites can not be killed by poisons sprayed onto the leaves, which may be devoured in feeding, but must be attacked by sprays which kill by contact.

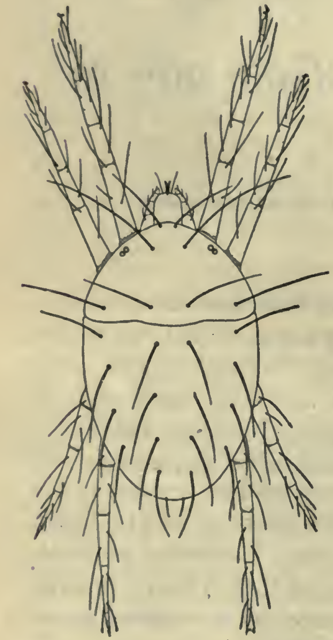

FIG. 1.—The red spider, *Tetranychus telarius:* Adult female. Greatly enlarged. (From Banks.)

EXTENT OF INJURY.

Unlike many pests the red spider does not occur continuously over large areas. Certain fields are infested while many others are free. Large fields are probably never damaged throughout, but smaller fields frequently become wholly affected. A thorough examination of all fields within 1 mile of the center of Leesville, S. C., was made during the height of the season with a view to determining the exact state of red-spider infestation in one locality. In all, 99 fields were examined as carefully as possible and about three-fourths of them were found to be infested. This occurrence was one of the severest and most general that has at any time come to the writer's attention. The worst infestation in the above-mentioned locality was one which spread from its point of origin until it extended in one direction 600 feet from the original source. (See fig. 5.) The area finally affected, semicircular in shape, comprised 13 acres, and within its boundaries the occurrence was general. While such a case as this is unusual, 4-acre or 5-acre spots with 25 to 100 per cent damage are frequently seen.

During 1912 about 20,000 acres of cotton in South Carolina were seriously infested by the red spider. Since the yield thus lost is about two-fifths of a normal crop on this area, or 2,716,000 pounds, it will be seen that at 12 cents per pound this lost lint represented a tax of $325,920. The cotton seed lost, at ordinary prices amounting to $67,900, brought the total levy on the South Carolina planters to about $393,820. In view of the fact that North Carolina, Georgia, Alabama, and Mississippi suffer similarly and are each considerably larger than South Carolina, it is estimated that during a severe red-spider year the southeast may suffer a loss of $2,000,000 from the ravages of this pest.

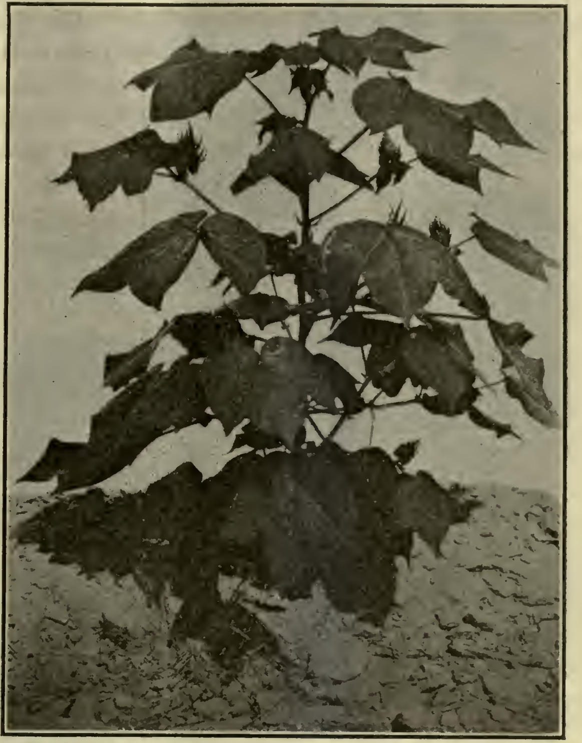

FIG. 2.—An uninfested cotton plant, growing in same field shown in figure 5, but just beyond the boundary of infestation by the red spider. (Author's illustration.)

DESCRIPTION OF THE RED SPIDER.

Both male and female red spiders are present on the plants. The color of the females is subject to considerable variation. At times it is rusty green, sometimes greenish amber, occasionally yellowish, at times almost black, but most often brick red, and a large spot of much darker color is usually seen along the back half of each side of the body. The males are considerably smaller than the females, more pointed behind, of a rusty salmon color, and the spots at the sides are not conspicuous. The red spider is in reality not a spider but a mite, and is more nearly related to the ticks than to the true spiders. As is usual with mites, both the male and the female have eight legs, but no wings. The females are less than one-fiftieth of an inch in length.

LIFE HISTORY AND HABITS.

The red spiders which pass through the winter are chiefly the mature females. Males, however, may also be seen at times during this season, and, indeed, during periods of mild weather eggs are laid and considerable development may take place. Upon several occasions at Batesburg, S. C., all stages of the red spider have been seen in winter on plants in outdoor locations. Feeding continues more or less, depending on the temperature, on several species of plants which bear leaves throughout the winter.

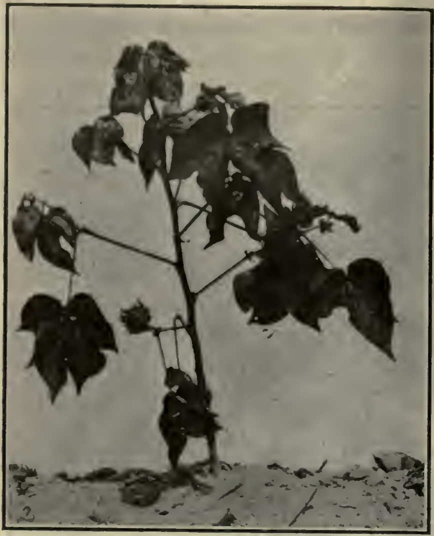

FIG. 3.—Cotton plant in an early stage of infestation by the red spider. Many leaves are discolored and some of the lower ones have dropped. (Author's illustration.)

The great mass of red spiders pass the winter on wild plants, and since these support the mite during the time of year when it is most difficult for the pest to survive it is clear that the wild plants are of great importance. Among the more common of these winter plants are hedge nettle, evening primrose, Jerusalem oak, wild blackberry, sow thistle, wild geranium, and wild vetch.

With the recurrence of warm spring days, the red spiders multiply much faster until their winter food plants become too crowded to support them properly. New feeding grounds then become necessary, and migrations take place which carry them to numerous species of spring plants and weeds.

The first spring generation of females usually develops about March 31. From this date until about May 31, when cotton becomes attractive to the pest, the red spider advances from the winter plants in several successive migrations. During this interval five broods of red spiders usually develop, so that each wintering female by the first of June has produced, theoretically, over 300,000,000 offsprings. In the meantime most weeds and garden plants that stand in the path of the red spider's advance become infested.

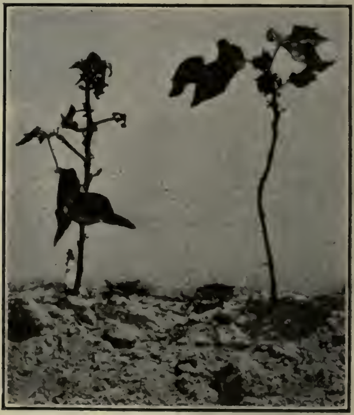

FIG. 4.—Cotton plant in well advanced stage of infestation by the red spider. Nearly all leaves, squares, and bolls have been shed. (Author's illustration.)

During the spring and summer months the red spider, in the latitude of South Carolina, requires on an average a little less than

11 days for the completion of a generation. In an average season at Batesburg, S. C., there are 17 generations of red spiders.

In developing from the egg to the adult stage the red spider follows one or the other of two distinct courses, depending on the sex. With the female, the egg hatches in about four days to a tiny, colorless, 6-legged form known as a larva, which feeds eagerly, and in about two days in summer time sheds its skin and becomes an 8-legged form called the primary nymph. The latter feeds in a manner very similar to that of the larva, and becomes greenish or yellowish in color with conspicuous blotches at the sides. At Batesburg this stage requires a trifle over two days for completion, when the skin is again shed and the secondary nymph appears. The latter lives about as the preceding stages do and becomes more nearly the size and color of the adult. After about one and nine-tenths days another molt or skin shedding occurs which gives origin to the adult female. Thus, for the most favorable season, the females require about nine days to mature.

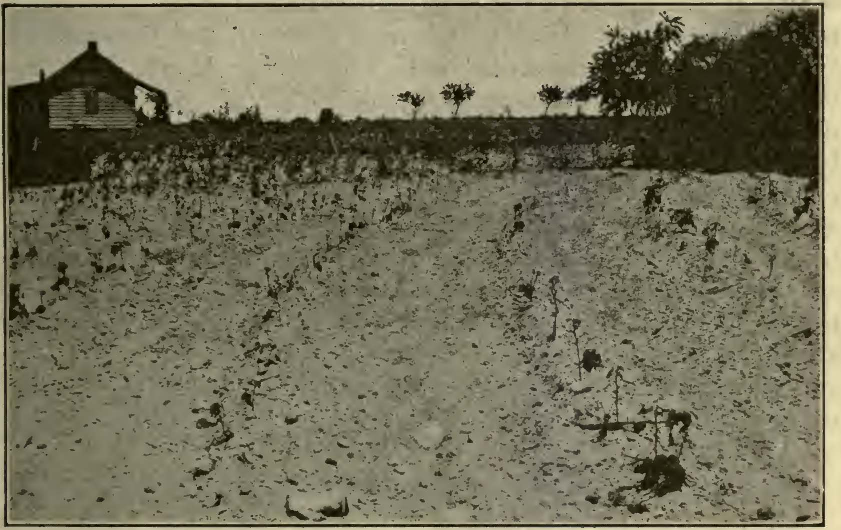

FIG. 5.—A severe example of red-spider work in a cotton field. Nearly all plants in the foreground are in the condition shown in figure 4. The source in this case was certain pokeweed stalks growing in the weed border seen in the upper right-hand corner of the figure. (Author's illustration.)

The development of the male is very similar to that of the female with the difference that the second nymphal stage is lacking. The other stages, however, are slightly lengthened, so that the male red spiders usually complete their development only one day sooner than do the females.

In establishing herself upon cotton the female selects a concave area between the under veins of the leaf and, after a brief feeding period of about 18 hours, begins to deposit her eggs. They are usually clustered rather closely, rarely occupying an area greater in size than that of a dime.

For about 8 to 10 days the female lays usually about six eggs per day, thus making a total of about 50 to 60 eggs. Feeding continues from time to time throughout the egg-laying period. The average duration of adult life in summer, in South Carolina, is about 12 days. This period increases as the weather becomes cooler. and in winter the adults often live for 150 days.

RELATION OF WEATHER TO BREEDING.

Climatic conditions influence the development of the red spider to a marked extent. The influence may be either harmful or beneficial. In the course of the year the occurrence of the pest undergoes many changes. During December, January, and February the red spider merely maintains itself, but during March conditions usually become a little more favorable. Through April and May development progresses most rapidly, and infestation reaches its height on miscellaneous plants by June 1. Beginning about the end of September, a reduction begins in the numbers of the red spider, and this reduction continues as the weather becomes colder, until, by the end of November, the low point is again reached. Hot, dry conditions, such as occur during times of drought, hasten development, while cool, wet weather retards it. A female laying normally about six eggs per day will, upon the occurrence of a hot day, suddenly increase the number, often to 15 or 20 eggs per day, or upon a chilly day the number deposited may drop as suddenly to one egg or none.

DISPERSION.

When cotton and other annual plants die in the late fall the red spiders are forced to seek green food. Many of them manage to locate upon the several kinds of weeds (mentioned on page 4) which remain green throughout the winter. Since these wild plants occur abundantly in the borders of fields and on terraces and roadsides, the pest frequently is found on cotton the following spring, in the portions of fields where planters fail to clear these borders of weeds.

The cultivated violet occurs frequently throughout the South, and remains green through the winter. Infested violet beds have been found from Virginia to Texas, and in many cases they are the sources of infestation to near-by cotton fields. The infestation to cotton may arise directly from violets, if the beds are within a few hundred feet of cotton (fig. 6), or from a series of migrations covering considerable distances.

A peculiar sort of red-spider infestation arises from pokeweed, which occurs commonly on terraces and along field borders. Owing to its long growing period it rarely becomes heavily infested until midsummer, so that infestation from this weed to cotton is usually noticed later than from violets or spring weeds.

It has been found that adult females are able to travel over smooth surfaces at the rate of about 5 inches per minute, or 600 feet in 24 hours. When forced to migrate through the scarcity of proper food, they commonly take to the ground and travel to other plants. During heavy rains many red spiders are dashed to the ground and carried considerable distances in the surface water, whereupon those not killed establish themselves on the plants that are near by. Heavy winds also at times blow them from place to place. When the injury becomes severe in a portion of a field it is common for the red spider to spread directly from plant to plant by means of the interweaving branches.

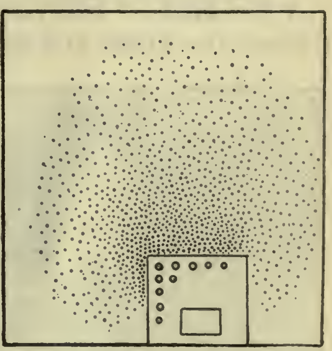

FIG. 6.—Diagram showing how violets growing in dooryard give rise to red-spider infestation in adjoining cotton field. The infestation is most severe near the yard. This diagram is typical of many cases found during 1911. (Author's illustration.)

PLANTS ATTACKED.

The red spider has been found breeding on nearly 200 species of plants, including weeds, ornamental plants, and garden and field crops. The following list of food plants, arranged in the order of their susceptibility to red-spider attack in the cotton belt, includes those most commonly infested: Cotton, cultivated violet, sow thistle, hollyhock, dahlia, garden beans, corn, tomato, onion, carnation, sweet pea, hedge nettle, nasturtium, morning-glory, clover, wild vetch, ironweed, Jerusalem oak, wild geranium, evening primrose, pokeweed, and strawberry.

NATURAL ENEMIES.

The red spider on cotton is attacked by over 30 predaceous enemies, which render valuable assistance in its control. Of these, 5 are mites, 3 are thrips, 4 are bugs, 4 are lacewing flies, 2 are midges, 4 are syrphid flies, 8 are lady beetles, and 1 is a caterpillar

REMEDIES FOR THE RED SPIDER.

PREVENTIVE MEASURES.

The solution of the red-spider problem must be accomplished through preventive efforts rather than curative, if it is to be done with economy. The location of the mites through the winter and spring, their rapid development on a few wild and cultivated plants, and the manner of dispersion of the pest lead to the following cultural recommendations.

WEED DESTRUCTION.

Many weeds and plants serve as sources of dispersion. By destroying, during the winter and early spring, pokeweed, Jerusalem oak, jimson weed, wild blackberry, wild geranium, and other weeds in and around cotton fields, the greatest step toward red-spider control will have been taken. This plan has been tested in several instances and has given complete immunity the following season.

CONTROL ON DOORYARD PLANTS.

A few kinds of cultivated plants, especially violets, remain green through the winter and are well adapted to serve as winter hosts of the red spider. Many cases of cotton infestation can be traced to near-by dooryards. The beds of violets and other plants should be thoroughly sprayed as soon as they show signs of infestation. The most satisfactory solution, where violets are concerned, consists in their removal or complete destruction.

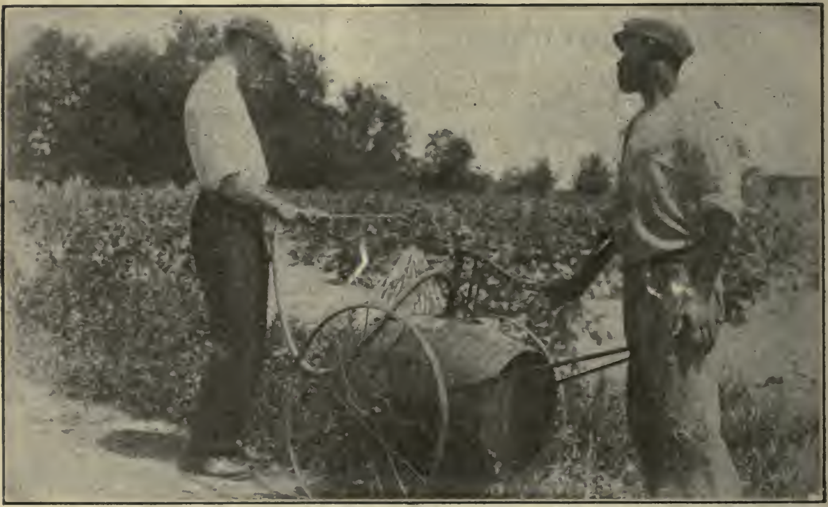

FIG. 7.—Portable barrel pump for application of herbicide to weed borders.

HERBICIDES.

Certain chemical sprays can be applied to weed and plant borders, which kill them rather quickly. Of these, sodium arsenate, used at the rate of 1 pound to 20 gallons of water, is the most satisfactory. The ease and speed of destruction that accompany the use of such a remedy justify urging its use as a substitute for the old-fashioned and tedious hoeing method. (See fig. 7.) It must be remembered, however, that sodium arsenate is a poison, and care should be taken to prevent horses and cattle from grazing on treated weeds.

SPACING.

Some have claimed that infestation spreads through a field only by means of the interlacing cotton branches, and that by increasing the spacing the spread of the red spider can be prevented. Since it is now known, however, that the mites commonly travel on the ground also, from plant to plant, it is easily seen that wide spacing of cotton plants will by no means entirely prevent the spread of the pest.

MAINTAINING MULCH.

By maintaining continually in fields a finely pulverized surface mulch the progress of migrating mites is somewhat retarded and the development of infestation correspondingly discouraged. The planting of cotton by the checking system permits the cultivation of each plant on four sides and is a good method from the viewpoint of the control of the red spider.

ROTATION.

Since the wild grasses and small grains appear to be about the only plants which are free from red-spider attack, there is little in the way of immune crops which can be used for the purpose of rotation. Furthermore, provided the sources of infestation were allowed to remain, the pest would surely reinvade fields, upon the return to cotton, even should the small grains or grasses be planted for a time.

FERTILIZERS.

Although the fertilizing of cotton land in no way discourages the development of red spiders, yet the judicious use of fertilizers invigorates the plants so that they are better fitted to overcome the injury.

REPRESSIVE MEASURES.

Under the heading "Repressive measures" may be discussed those measures which can be taken to combat the pest when it has gained entrance to cotton fields. It has been demonstrated that it is possible to eradicate the pest from infested fields.

By keeping a constant watch of cotton fields the earliest affected stalks may be detected and destroyed. In this method it is usually necessary to repeat the operation several times, since certain plants are likely to be overlooked during the first inspection. Great care should be taken to locate every plant which shows infestation, and these must be taken from the field, without brushing against healthy plants, and burned immediately. If infestation has not advanced too far, the prompt application of this method is usually effective.

If infestation has spread until a considerable patch has become involved, more drastic steps are necessary than those just mentioned. Where a continuous area of infestation occurs in a large field, it is often advisable to plow up the worst affected portion and spray the rest of the infestation in order to save the balance of the field. The stalks should be quickly piled up and burned with the aid of straw or light trash. Such a severe measure should only be resorted to in extreme cases, and the planter concerned must be the judge of its advisability.

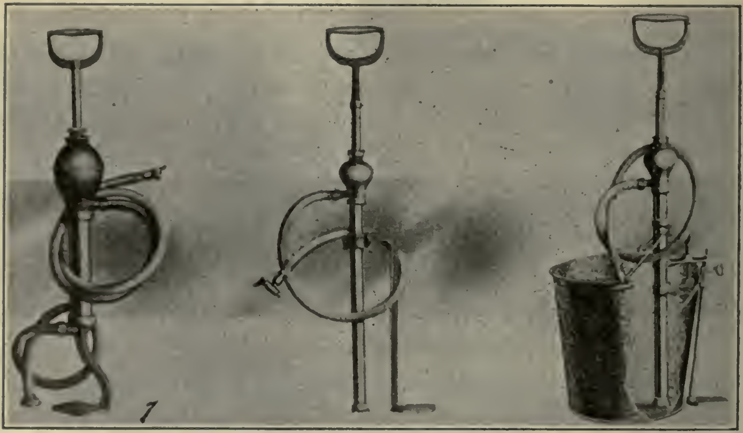

FIG. 8.—Bucket spray pump. (From Quaintance illustration.)

INSECTICIDES.

Out of 75 different spray combinations tested against the red spider on cotton the following have been found to be thoroughly satisfactory: (1) Potassium sulphid (1 ounce to 2 gallons water); (2) lime-sulphur (homemade or commercial); (3) kerosene emulsion (prepared according to usual formula); (4) flour-paste solution (1 gallon stock paste to 12 gallons water). Spraying for the red spider is effective if it is done with extreme care. The foregoing sprays, when properly applied, kill all mites, but *a second spraying, one week later, is necessary to kill the individuals that were in the egg stage at the time of the first spraying.* Arsenical sprays are of no use against red spiders.

SPRAYING OUTFITS.

The sort of outfit to be used for spraying the red spider on cotton depends mainly on the extent of the occurrence. Many prefer to use a small tin atomizer when only a score or so of plants are to be treated. These instruments are very economical of liquid and throw a very fine, vapory spray which reaches all parts of the plants. The bucket pump (fig. 8) and knapsack pump (fig. 9) come into use in cases of considerable scattered infestation, or for treatment of a few plants in tall cotton where the platform pump would be undesirable. The most economic outfit for a severe case comprising several acres consists of a barrel pump carried through the field on a wagon or specially constructed vehicle of some sort. Figure 10 is from a photograph of a portable outfit used very successfully in demonstration work in North Carolina. It consists of a platform built upon the axle and shafts of a dismantled hayrake. The wheels are large, bringing the axle well above the ground, so that the vehicle does very little damage to the plants. Since the gauge of the outfit is 8 feet, it straddles two cotton rows, the single draft animal walking in the middle between these rows. A barrel pump with a capacity of 50 gallons is mounted on the platform. A boy drives, one man pumps, and two men handle the two sprayers. Thorough treatment of 4 acres per is readily obtainable with these devices.

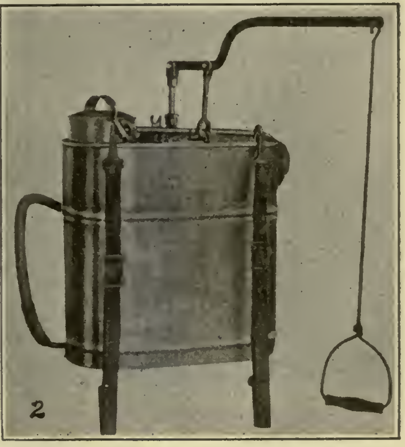

FIG. 9.—Knapsack sprayer. (From Quaintance.)

NECESSITY FOR THOROUGH SPRAYING.

Some dissatisfaction has been experienced among certain planters who have undertaken to check the ravages of the red spider by spraying. With pests which devour the entire leaf, such as potato "bugs," cotton caterpillars, etc., even the careless application of Paris green to the top of the foliage often proves entirely satisfactory. This is explained by the fact that pests of that kind are constantly moving from leaf to leaf and are sure to get some of the poisoned foliage. Also, since these insects usually eat completely through the leaf, it matters little upon which side the poison falls. With the red spider, however, it is very different. A contact insecticide is absolutely necessary, and since the mite spends its life on the underside of a single leaf it is most important in spraying to *hit the entire underside of every leaf of an infested plant.* Careless spraying is certain to yield unsatisfactory results.

SUMMARY OF REMEDIES.

To prevent injury to cotton by red spiders the following steps should be taken: (1) Destruction of all weeds around the farm during the winter and early spring; (2) spraying of cultivated plants around the dwellings; (3) maintaining a finely pulverized surface soil; (4) destruction of early infested plants or large areas of heavy infestation by plowing up and burning; and finally (5) spraying with potassium sulphid, lime-sulphur, kerosene emulsion, or a flour-paste solution if the infestation is more or less general.

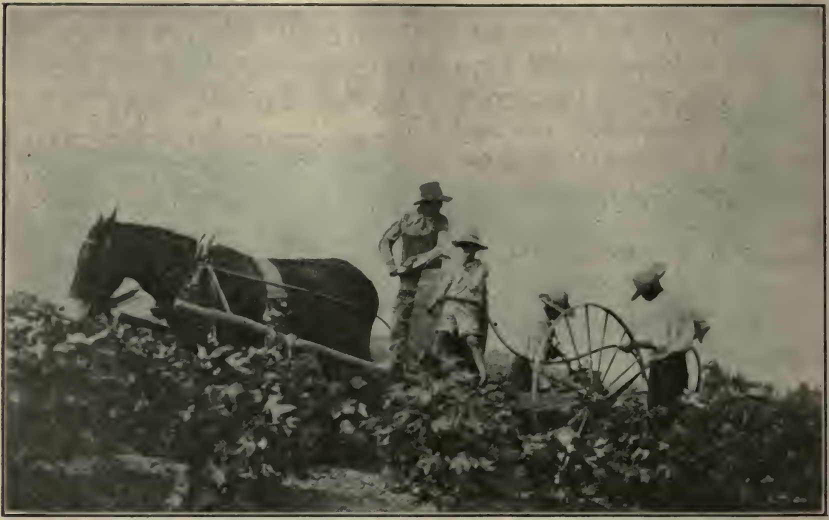

FIG. 10.—Ideal spraying outfit for treatment of considerable red-spider infestation.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 736 JULY 17, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

GINSENG DISEASES AND THEIR CONTROL.[1]

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INTRODUCTION.[2]

The average yield of ginseng per acre in the United States is not more than one-sixth to one-third of what might reasonably be expected, the shortage being caused almost entirely by the numerous diseases which attack the crop. The time of appearance and the severity of these diseases in any given locality depend on climate, soil, and cultural relations, but so far as observed by the writers they are not confined to any particular region. Generally speaking, the same diseases are found in all ginseng-growing sections, from New York to the Pacific. The purpose of this bulletin is to bring to the attention of ginseng growers the most recent information regarding the symptoms, cause, and control of the various diseases attacking the ginseng plant.

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[1] For technical descriptions of the different diseases, see Bulletin No. 250 of the Bureau of Plant Industry, entitled "The Diseases of Ginseng and Their Control."

[2] This bulletin contains the results of cooperative work between the Bureau of Plant Industry, the New York (Cornell) Agricultural Experiment Station, the Wisconsin Agricultural Experiment Station, and the Michigan Agricultural Experiment Station.

ALTERNARIA BLIGHT AND ROOT-ROT.

Alternaria blight has long been known as one of the most widespread of ginseng diseases, and the fact that the same disease may also affect the root, taking the form of a serious root rot, as recently discovered by one of the writers, shows that it is of even greater importance than hitherto supposed.

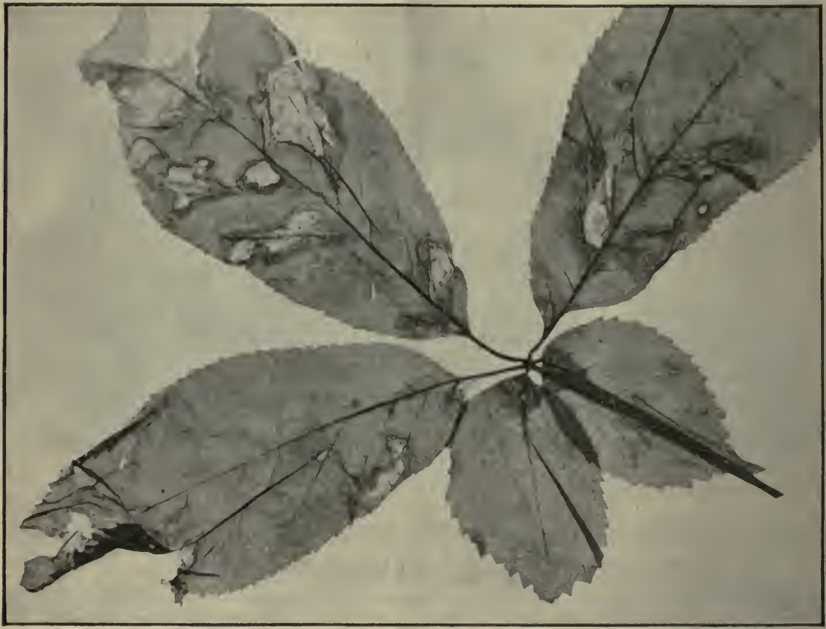

FIG. 1.—Leaves of ginseng affected with Alternaria blight.

Symptoms and cause.—During the spring the stems of some of the plants in gardens in which the disease existed the previous season show dark-brown spots or cankers of different sizes just above the surface of the ground. These spots, which are usually the first symptoms of the disease, enlarge and become velvety or fuzzy in appearance. A little later large dead spots in the leaves begin to appear. At first these have a water-soaked appearance, but gradually they become dry and papery in the center, with a darker, yellow-brown border (fig. 1). In later stages the leaflet may droop at the point of attachment to the leafstalk or where the leafstalk rises at the top of the stem. The affected part becomes coated with a velvety brown dust at the point where it bends over. The seed heads also are often affected, and as a result the berries shell (fig. 2). In severe cases practically every plant in the bed becomes blighted (fig. 3).

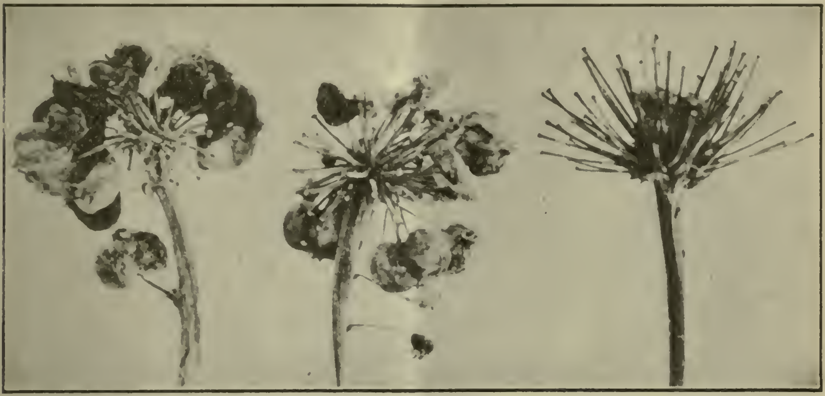

FIG. 2.—Ginseng seed heads affected with Alternaria blight.

Affected roots rot very slowly. This rot has no odor. The lesions are dark brown to almost black, and the rotted roots never become soft (fig. 4). So far as known it would seem that only roots which have been injured in some way are attacked.

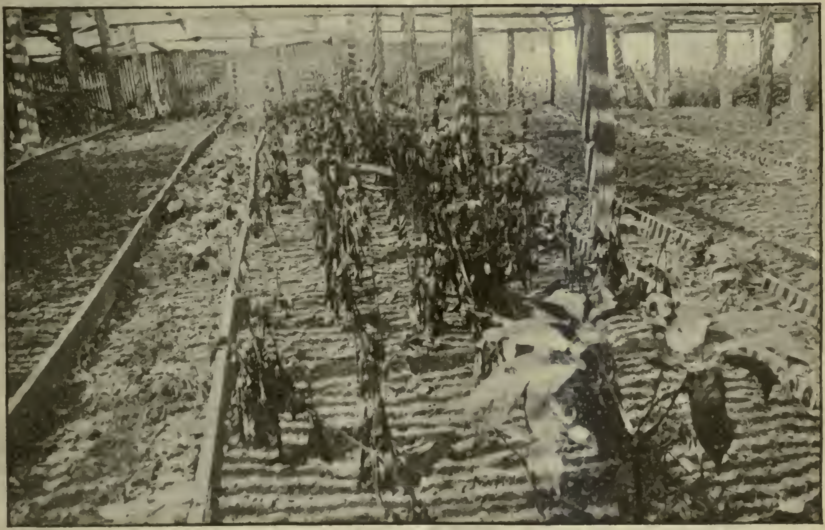

FIG. 3.—Bed of ginseng plants, showing the result of an epidemic caused by Alternaria blight.

The disease is caused by a fungus,[1] a minute moldlike growth. This lives and grows within the plant and pushes to the surface stalklike branches, on the ends of which the spores (microscopic seedlike bodies) are produced. The great number of these spores on the surface of affected stems gives the velvety brown or fuzzy appearance above mentioned (fig. 5). The spores are distributed by the wind and carried on the clothing from diseased to healthy gardens, and during rainy periods such spores as have lodged on the plants germinate and produce sprouts (germ tubes) which penetrate the tissues.

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[1] *Alternaria panax* Whetzel,

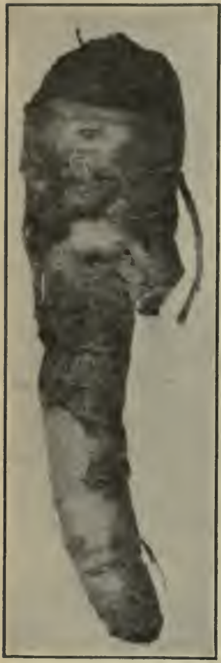

FIG. 4.—Ginseng root, showing Alternaria root-rot.

Control.—Sanitary measures, such as the removal and destruction of diseased tops, are of the greatest importance. After the tops die down the beds should be covered with a layer of dry straw and burned over, or if this can not be done they should be sprayed with a solution of copper sulphate, 1 pound to 5 gallons of water. Spraying the plants during the growing season is the best means of controlling the disease. The most satisfactory results were obtained from Bordeaux mixture, 3–3–50 (see p. 19), to which 2 pounds of lead arsenate for every 50 gallons of the mixture had been added (fig. 6). All susceptible parts of the plants should be kept well covered with the Bordeaux mixture. The first application should be made when the plants are pushing through the soil, and the treatment should be continued until they are up; the second when the leaves are fully expanded; and the third just after blossoming, in order to protect the seed heads.

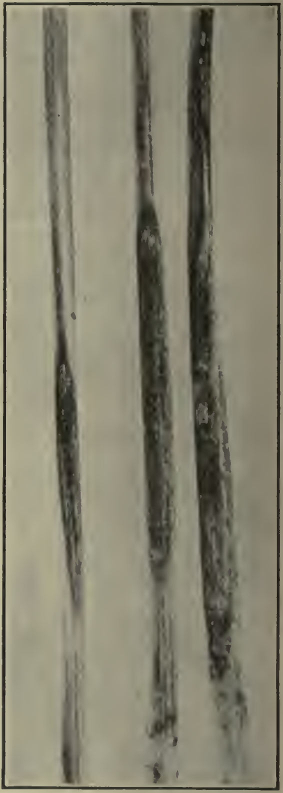

FIG. 5.—Stems of ginseng, showing a velvety brown or fuzzy appearance, caused by Alternaria blight.

PHYTOPHTHORA MILDEW AND ROOT-ROT.[1]

Phytophthora mildew and root-rot, which is also known as mildew, Japanese mildew, and Phytophthora soft-rot, affects the leaves, stems, and roots of plants of all ages and is very widespread. In some sections it kills from 20 to 30 per cent of the plants.

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[1] A detailed discussion of this disease is to be found in New York (Cornell) Agricultural Experiment Station Bulletin 363. Recent work indicates that a root rot resembling the Phytophthora root-rot is caused by a species of Fusarium or Ramularia. Roots attacked by the latter are softer and are always accompanied in the last stages by a strong odor.

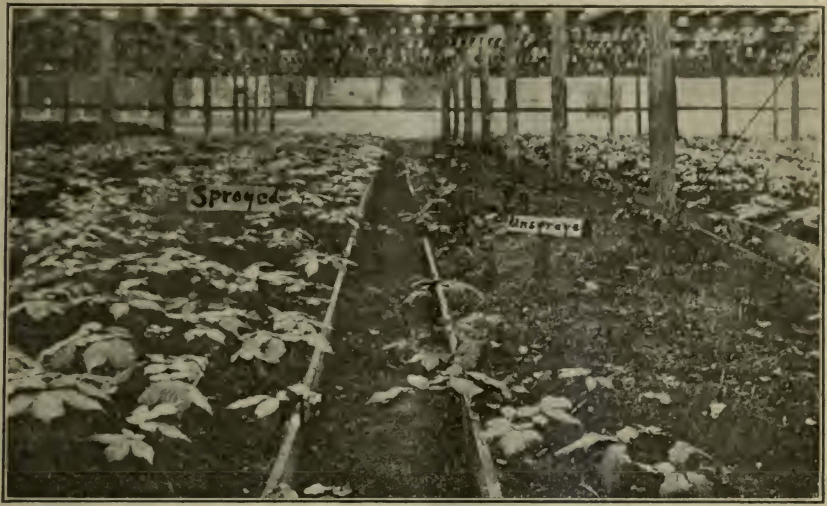

FIG. 6.—Sprayed and unsprayed ginseng plants attacked by Alternaria blight. Aside from spraying, both beds received the same treatment.

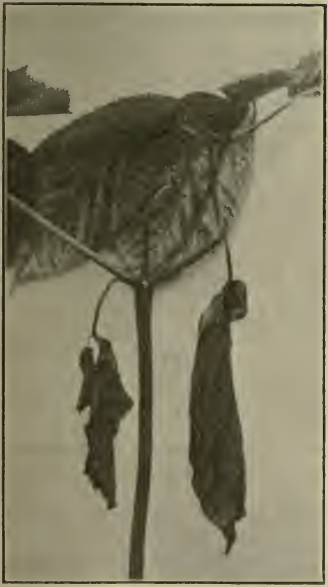

FIG. 7.—Ginseng plant, showing characteristic symptoms of Phytophthora mildew.

Symptoms and cause.—The leaflets at the tops of affected plants often droop at the tip or base of the petiole (fig. 7) in much the same way as those affected with Alternaria blight, and the stems after a time become hollow and somewhat discolored. The leaf blades also show characteristic spots of varying sizes, these in the early stages being much like those caused by Alternaria blight. A week or two after the spots appear the centers become white, but the margins remain a dark water-soaked green (fig. 8) and never show the yellow-brown margins which characterize the Alternaria spots. The roots, which may also be attacked, show a semisoft rot (fig. 9) and in a short time become entirely involved. If such roots are allowed to remain in the soil for any considerable length of time various organisms, such as Fusaria and bacteria, enter the diseased tissues and cause them to become soft, and at this stage the disease is often accompanied by the disagreeable odor characteristic of vegetable decay.

The disease is caused by a fungus[1] which is closely related to that causing the late-blight of potatoes, and in many respects this disease resembles the latter. The fungus produces two kinds of spores; that is, thin-walled summer spores on the surface of the diseased parts, which serve to spread the disease during the growing season, and thick-walled winter spores in the tissues of the plants, which help to carry the fungus through the winter. The latter, which seem to be favored by an abundance of moisture, germinate in the spring, and during favorable periods throughout the growing season produce summer spores. These spores are in turn carried by the wind to the tops of healthy plants and by soil water to the roots. Infection in the spring may start either in the root and spread upward or in the stem and spread downward to the root, but in either case both root and top may become diseased.

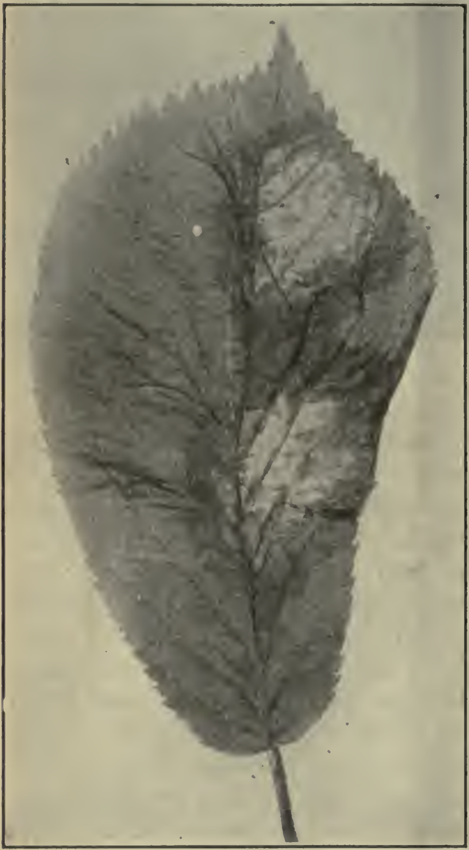

FIG. 8.—Leaf-spot of Phytophthora mildew on ginseng.

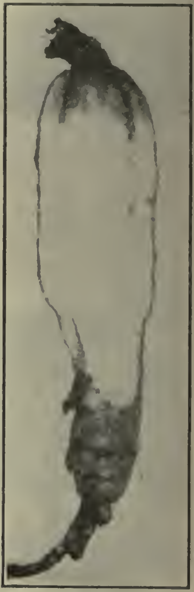

FIG. 9.—Root-rot of ginseng caused by Phytophthora mildew.

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[1] *Phytophthora cactorum* (Con. and Leb.) Schröter.

Control.—Since the summer spores are produced very early in the spring, the tops of the plants should be protected against infection. This can be done by spraying with Bordeaux mixture (3–3–50), as in the case of Alternaria blight. To prevent the disease from extending down the stem into the roots, the tops of plants showing wilting or drooping should be removed by cutting them off at the crown. If the root is affected it should be carefully removed from the bed and destroyed, and the soil in which it grew should be disinfected with formaldehyde, 1 part to 50 parts of water, or with copper sulphate, 1 pound to 5 gallons of water, these to be applied at the rate of about 1 gallon per square foot of soil. As abundant moisture favors the development of the winter spores, it is a good practice to tile-drain the land before making up the ginseng beds.

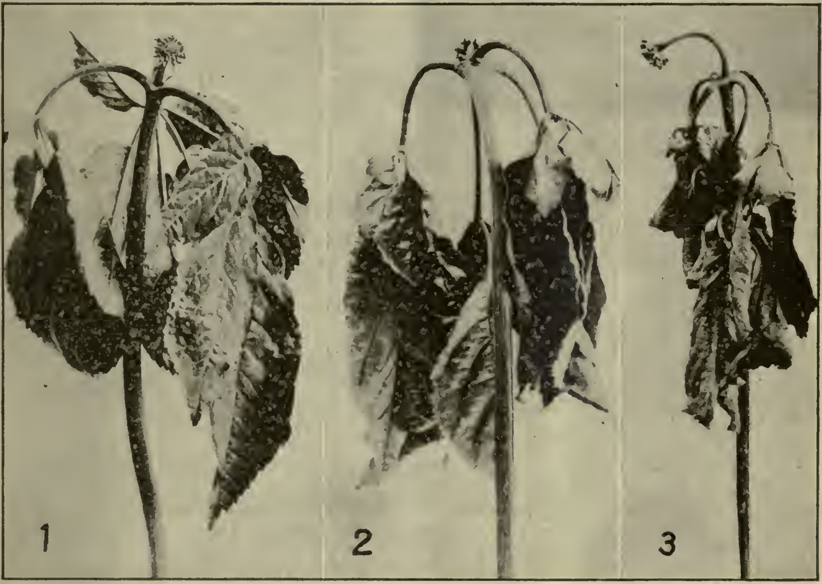

FIG. 10.—Ginseng plants, showing Acrostalagmus wilt in various stages: (1) Earliest stage; (2) a week or ten days later; (3) last stage.

A garden once infected should not be used for a number of years, as it has been found that the winter spores can live in the soil at least four years. Where for some reason it is desirable to use infected land, it should be disinfected with either steam or formaldehyde (pp. 20–21), both of which have given good results.

ACROSTALAGMUS WILT.

Acrostalagmus wilt is a disease of the older ginseng plants. During the past two years reports of its occurrence have been fewer than previously. The loss which it causes seldom exceeds 5 to 10 per cent of the crop.

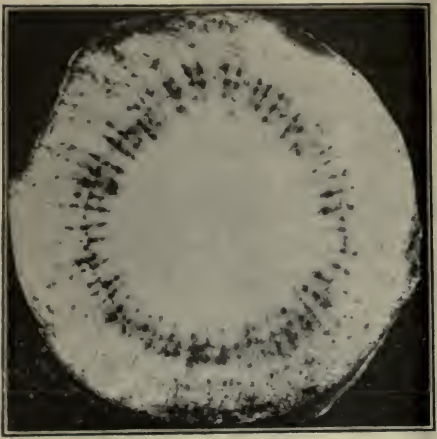

FIG. 11.—Section of a ginseng root, showing a discolored ring of water-conducting tubes, due to Acrostalagmus wilt.

Symptoms and cause.—Although this is a root disease, the first symptoms appear in the tops, which gradually wilt. Affected plants are scattered here and there in the bed. At first, the leaves become flagged, and gradually the entire top wilts and dies (fig. 10). Externally the roots appear to be healthy, but if cut across, a yellow zone, extending part or all the way around, will be found (fig. 11).

The disease is caused by a fungus[1] which produces minute spores on the roots. The spores live in the soil and serve to spread the pathogene to healthy roots. These spores give rise to the rootlike threads of the fungus, which penetrate the healthy ginseng root and establish themselves in the sap-tube region (fig. 12). They injure the sap tubes, causing the yellow zone above described and bringing about the wilting of the tops.

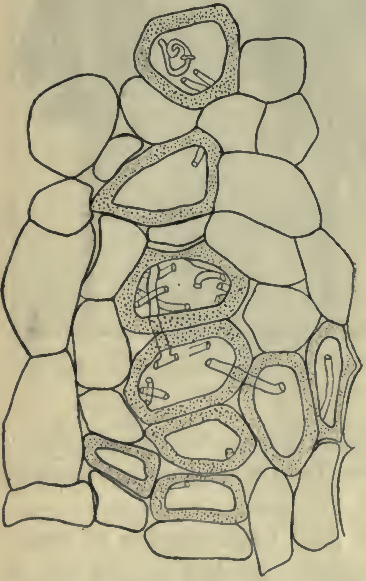

FIG. 12.—Section through a ginseng root, showing water-conducting vessels filled with threads of the fungus causing the wilt. (After Van Hook.)

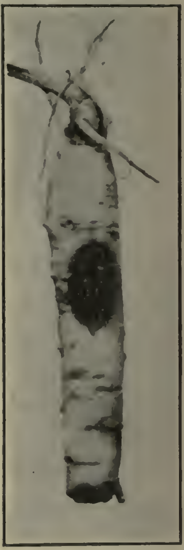

FIG. 13.—Thielavia rot on an older ginseng root.

Control.—As the older roots only are affected, they should be dug and dried, so as to remove the source of infection, and the soil in which a diseased crop has been grown should be disinfected by the use of either formaldehyde or steam.

---

[1] *Acrostalagmus* sp.

THIELAVIA ROOT-ROT.

The Thielavia root-rot affects plants of all ages, but is most common in the seedling beds, many of which are often rendered worthless. Specimens showing this disease have been collected from 11 States.

Symptoms and cause.—The rotting may occur on any portion of the roots of older plants. The spots have a grayish black appearance, but do not penetrate deep into the root (fig. 13). In the case of seedlings the end of the taproot and the fibers are attacked, root hairs and many of the smaller rootlets are lacking, and instead of being long the taproot frequently becomes knoblike (fig. 14).

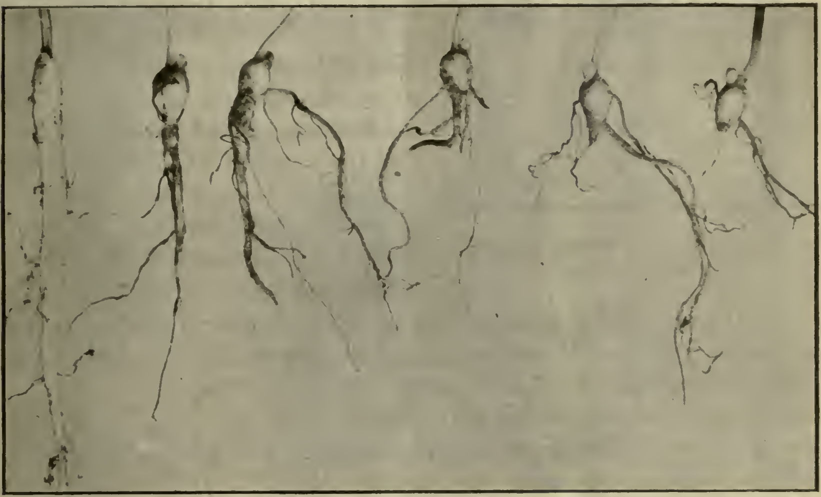

FIG. 14.—Roots of seedling ginseng plants, showing the effect of Thielavia rot.

The disease is caused by a fungus,[1] and its ability to attack plants is favored by an alkaline condition of the soil.

Control.—Where ginseng is found in the natural forest the soil is acid, and since alkaline soil favors the development of the disease, the grower should try to have the soil of the ginseng garden of an acid reaction. This can be done by applying acid phosphate at the rate of 1,000 to 2,000 pounds per acre, the amount depending on the previous treatment of the beds and the alkaline condition of the soil. It is likewise obvious that lime, ashes, or other alkaline fertilizers should not be applied to ginseng beds. Before being sown to seed, infected beds should be treated with steam or formaldehyde.

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[1] *Thielavia basicola* (B. and Br.) Zopf.

SCLEROTINIA WHITE-ROT.

Sclerotinia white-rot occurs in most ginseng-growing regions, but has never been known to be epidemic in the ginseng garden. It also affects lettuce, beets, tobacco, cucumbers, and many other cultivated plants, and this probably explains its distribution in ginseng gardens, in many of which some of these crops were previously grown.

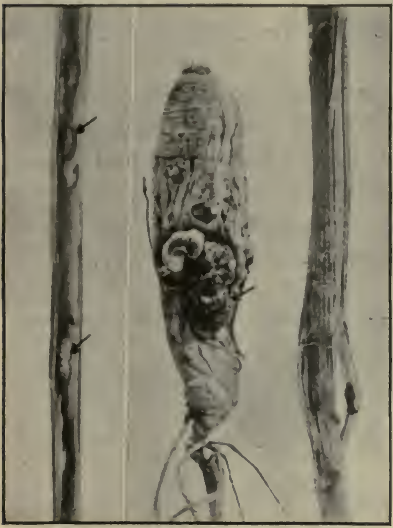

FIG. 15.—Sclerotinia white-rot on ginseng root and stems.

Symptoms and cause.—The disease may affect the stem and root (fig. 15), but in no case is a spotting of the foliage known. Soon after the stem is affected it loses its green color and becomes hollow. On the outside of diseased roots, and often within the hollow of diseased stems, are to be found hard black bodies, often a quarter of an inch long. These are resting bodies of the causal fungus and are called sclerotia. The disease may start at any point in the root and gradually work its way up through the stem, or it may start in the stem and work downward toward the root. When the soil is wet after a continued rainy spell the disease spreads very rapidly, entire roots sometimes rotting completely in five days. The tissue of diseased roots becomes soft, cheesy, and brittle, but has no bad odor.

The disease is caused by a fungus[1] which is characterized by its hard, black sclerotia, or resting bodies, varying in size from a pinhead to half an inch in length. The sclerotia remain in the soil or in the dead tissue during the winter, and in the spring produce small, cuplike structures (fig. 16), which contain numerous spores. These spores are carried by the wind to the stems, where they germinate and send rootlike threads into the tissues. The roots

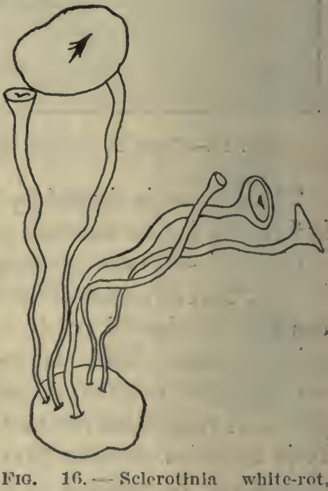

FIG. 16.—Sclerotinia white-rot, showing cup-shaped bodies which arise from the sclerotia of the fungus.

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[1] *Sclerotinia libertiana* Fckl.

may be infected by the threadlike growth of the fungus from the sclerotia, especially where there is an abundant supply of moisture.

Control.—Good drainage and aeration are so closely connected with the growth of the fungus that they are the prime factors to be considered in connection with the control of the disease. The diseased tops and roots should be removed and the soil from which the latter were taken should be disinfected with a solution of formaldehyde, 1 part to 50 parts water, or with copper sulphate, 1 pound to 10 gallons of water. This will tend to prevent the formation of the sclerotia in the soil.

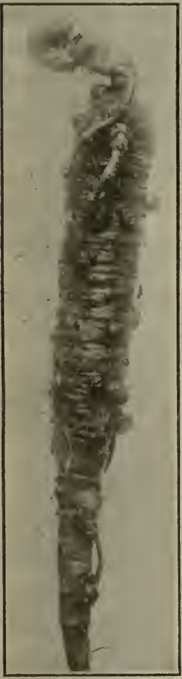

FIG. 17.—Sclerotinia black-rot, showing ginseng root and bud affected the first year. The surface is black, but the root is plump and firm.

SCLEROTINIA BLACK-ROT.

Sclerotinia black-rot was doubtless originally a disease of wild ginseng. It also affects another common forest plant known as false Solomon's-seal,[1] and without question is often introduced into ginseng gardens through the forest soil used by many growers in making up their ginseng beds.

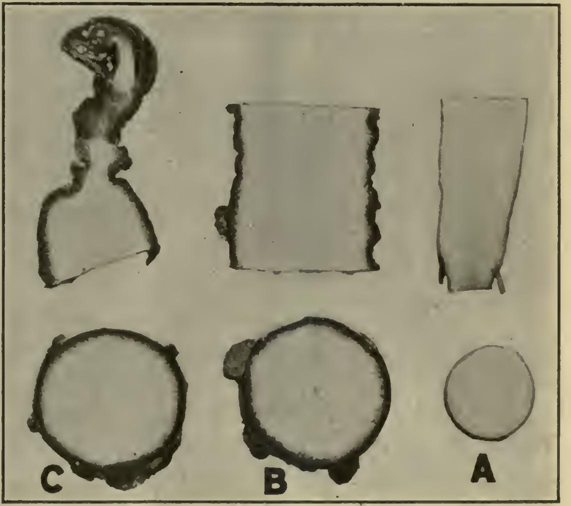

FIG. 18.—Sclerotinia black-rot of ginseng. Sections through root and bud, showing coal-black margins the first year. *A*, A healthy root; *B* and *C*, diseased.

Symptoms and cause.—This disease affects the roots only and is distinctly a winter disease in that it makes no progress during the growing season. The most striking sign of the presence of this disease in a garden is the failure of plants to come up in certain spots or areas in the beds. On digging into such spots the black mummy-like roots will all be found in place. Frequently two winters pass before the root is finally destroyed. During the first season after the root is affected it remains plump and firm, but the outer surface becomes coal black (fig. 17), while during the second year it becomes black throughout, shrinks, and finally decays. A section through an affected root during the first year will show the coal-black outer rind (fig. 18).

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[1] *Smilacina racemosa.*

This disease is caused by a soil fungus.[1]

In the autumn, small black enlargements, sclerotia (fig. 19), are formed, and these produce mycelia or threadlike growths on the outer tissues of the root, which grow through the soil and infect surrounding healthy plants. Cuplike bodies (fig. 19) are also produced, and these bear spores which are washed into the soil by rains and infect the healthy roots.

Control.—All the black roots in a diseased area should be removed and destroyed and the soil thoroughly disinfected with a solution of formaldehyde, 1 part to 50 parts water.

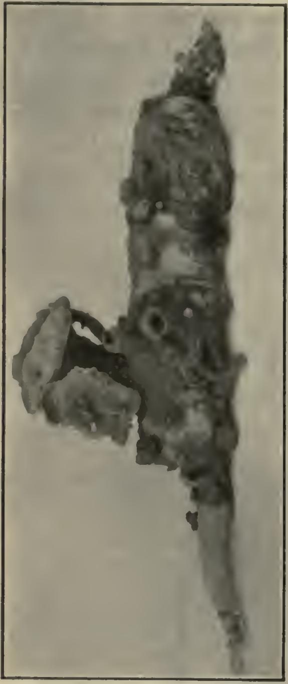

FIG. 19.—Sclerotinia black-rot, showing cuplike bodies formed the second season on an affected ginseng root.

DAMPING-OFF OF SEEDLINGS.

Damping-off is the name applied to some diseases of seedlings caused by certain organisms that live in the soil and are especially favored by excessive moisture and lack of aeration.

Symptoms and cause.—The stems of affected plants become soft and rot at the surface of the soil and the tops drop over (fig. 20). The common damping-off fungus[2] and the "sterile" fungus Rhizoctonia have been found associated with these diseases, and occasionally the mildew fungus[3] produces the effects described.

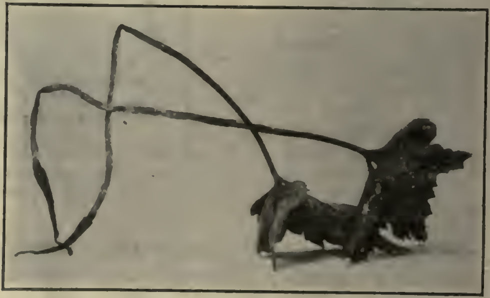

FIG. 20.—Ginseng seedlings affected with damping-off. Note the sharp angle where they bend over. (After Van Hook.)

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[1] *Sclerotinia smilacina* Dur.=*S. panacis* Rankin.

[2] *Pythium debaryanum* Hesse.

[3] *Phytophthora cactorum* (Con. and Leb.) Schröter.

Control.—Good drainage and aeration are of the greatest importance in raising seedlings; consequently, tile drainage is recommended. Damping-off caused by Rhizoctonia has been checked by sprinkling clean sand on the surface of the bed to a depth of one-fourth to one-eighth of an inch. Where the garden is small and it is possible to do so, it is well to sprinkle it with sand several times during the growing season. When the seedlings are planted in drills the loosening of the soil after rains is very helpful. Before seed is planted in beds in which ginseng has been grown the soil should be

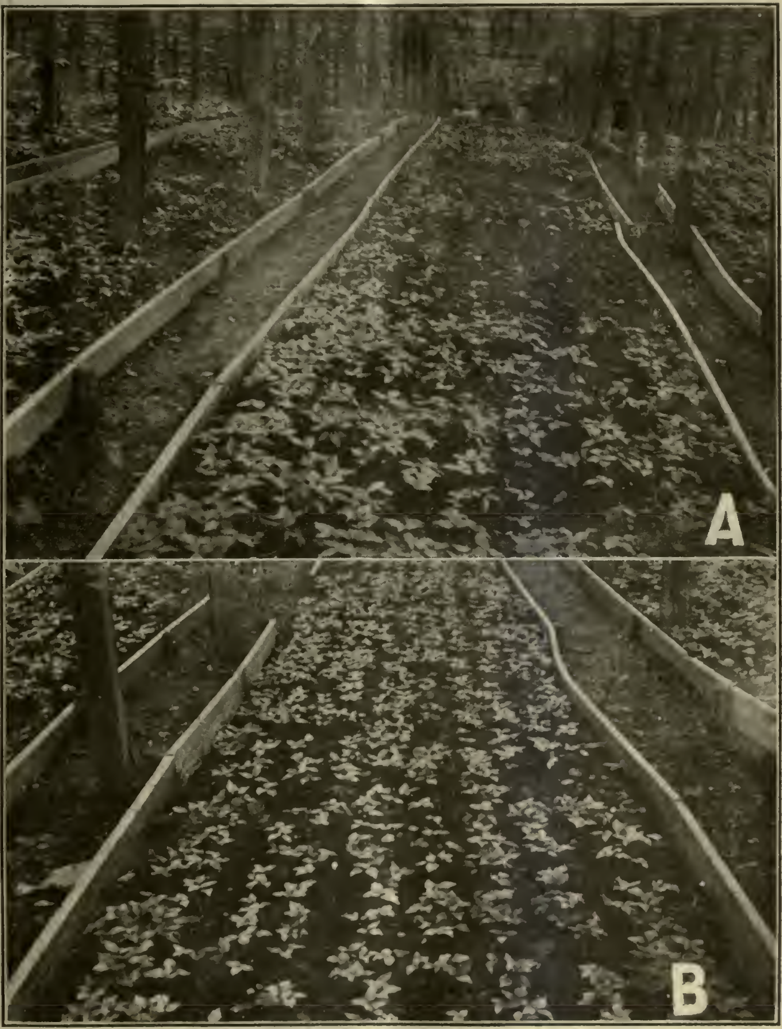

FIG. 21.—Adjacent ginseng seedling beds, showing the effect of formaldehyde treatment: *A*, Not treated; *B*, treated with formaldehyde solution before planting.

disinfected with a solution of formaldehyde, 1 part to 50 parts water. This should be done a week or ten days prior to planting, according to the specific directions given on page 21. Excellent results have been obtained by such disinfection (fig. 21, *A* and *B*). When damping-off spots appear in a bed of seedlings its spread may be checked by drenching the infected portions of the bed with a solution of formaldehyde, 1 part to 100 parts of water. Steaming is also very effective.

PAPERY LEAF-SPOT.

Papery leaf-spot is common during dry seasons. It is not of a parasitic nature, and consequently never spreads from plant to plant. Usually only a few plants in certain places in the garden show the trouble.

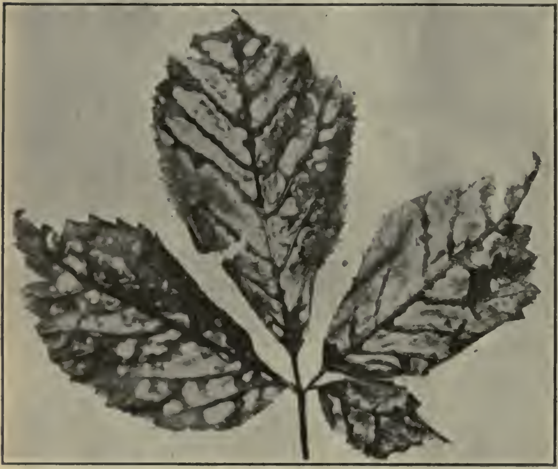

FIG. 22.—Leaves of ginseng affected with papery leaf-spot.

Symptoms and cause.—The disease is characterized by the spotting of the leaves (fig. 22), the spots appearing between the veins or along the margins. The spots are transparent, often have a yellowish tint, vary from small and circular to large and oblong or irregular, and are of a papery texture, the last portion to become affected being the large veins and the midrib. The spots produced by this disease differ from other spots in that they are more transparent when examined against the light.

The trouble is caused by an insufficient supply of water, and this may be brought about by various causes, such as lack of rainfall and consequent lack of moisture for the plants; large roots of trees within the beds, which exhaust the water supply; insufficient shade and consequent rapid drying out of the moisture; excessive use of nitrate of soda; and, as a result of fungi or unfavorable conditions, a lack of fine root hairs to take up the moisture from the soil. Under the conditions last mentioned the papery leaf-spot may occur in beds which have a sufficient supply of moisture.

Control.—The only remedy that can be suggested, as indicated by the foregoing, is the correction of unfavorable conditions. To this end tile drainage should be used, as it equalizes the moisture and protects the plants in dry seasons. Beds should not be made near large trees, and the plants should be kept in a healthy condition in order that they may have a large number of feeding roots for the absorption of water

SPRAY INJURY.

Spray injury results from the use of spray mixtures, as the term indicates. Injury from spraying is seldom very severe, but attention is called to it so that it may not be mistaken for a disease.

Symptoms and cause.—The symptoms of spray injury depend on the mixture or solution used. Those which have heretofore caused injury are Bordeaux mixture and lime-sulphur. When an application of the former is followed immediately by cold weather it will often cause a browning and then a shriveling of the edges of the leaves, or even the death of the tender young tops and stems, and on the older leaves small, circular brownish spots. When applied in early spring lime-sulphur causes a stunting of the entire plant, while the edges of the leaves may also show symptoms similar to those caused by Bordeaux mixture.

The foliage of ginseng seems to be particularly subject to injury from lime-sulphur, but the reason for this is unknown. In the case of Bordeaux mixture the cause of injury is improper preparation, too small a supply of lime in the mixture being the usual source of the trouble.

Control.—Lime-sulphur should not be used for spraying ginseng, and in preparing Bordeaux mixture care should be taken to use a high grade of lime and enough lime milk (not the clear lime water) to combine with all the soluble copper. (See p. 19.)

RUST.

Symptoms and cause.—Rust attacks the roots, causing them to appear rusty or copper colored, but never attacks the tops. The disease occurs on plants of all ages, but affected plants usually reach maturity.

All efforts to find a definite organism associated with the disease have failed. Doubtless several of the root rots (especially those caused by *Alternaria panax* and *Thielavia basicola*) are commonly included, with other brown rots and rusty discolorations of the roots, under this name "rust."

Control.—No satisfactory way of controlling rust has been worked out, but one of the writers obtained good results from sterilizing the soil with steam.

NEMATODE ROOT-GALL.

The nematode gall is a root trouble, but in rare instances the stems also show the galls. The disease has been reported from all the ginseng-growing sections.

Symptoms and cause.—The severity of the disease may vary, but the grower should have no trouble in recognizing it by the nodules or swellings found on the fibers and smaller rootlets (fig. 23) and sometimes on the main root. After a time these swellings, or galls, as they are sometimes called, turn brown, become water-soaked, and finally decay.

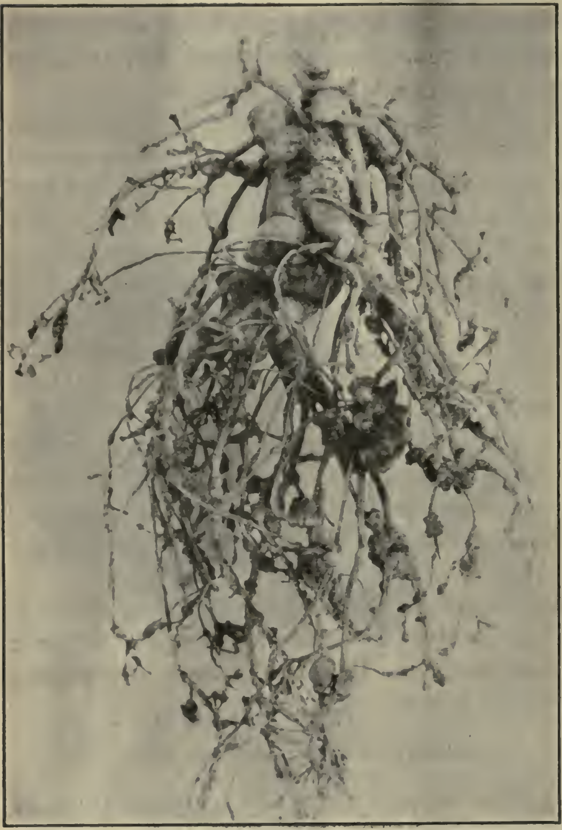

FIG. 23.—Ginseng roots, showing nematode galls.

This disease is caused not by a fungus, but by a minute parasitic eelworm,[1] which also causes root galls on many common weeds and cultivated plants. This parasite lives in the soil, where it comes in contact with and penetrates the tender tissues of the root, and by stimulating the root tissues produces the galls. It lays its eggs within the tissues of the root or in the soil, and here they hatch and produce another generation of worms. A number of generations may be produced in a single summer. The worms pass the winter as larvæ, either in the soil or in the root.

Control.—It has been suggested that a rotation with goldenseal would rid the soil of nematodes, but the work of one of the writers has shown that this plant also is attacked by the parasite. In view of this fact, the only remedy that can be suggested here is the sterilization of the soil with steam. Soil treatment with formaldehyde has not proved effective. To prevent the infection of healthy roots care should be taken to avoid the transfer of infested soil or diseased roots from one bed to another. As the worms are usually brought into clean gardens in the roots of nursery stock, great care should be taken in selecting healthy roots.

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[1] *Heterodera radicicola* (Greef) Müller.

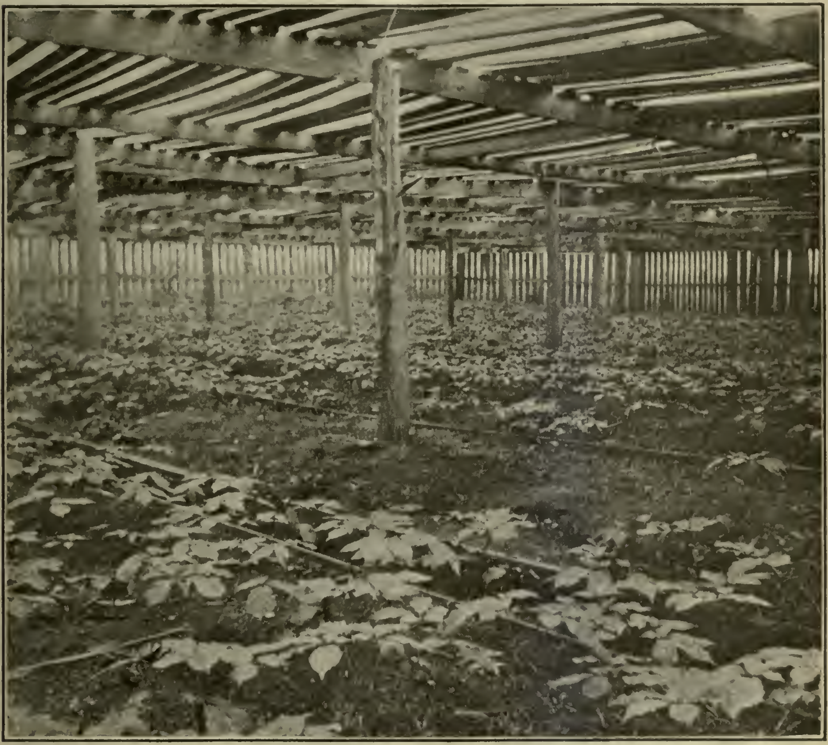

FIG. 24.—Ginseng bed, showing plants killed by lightning around a post which also was damaged.

LIGHTNING INJURY.

Recently one of the writers observed a striking case of injury from lightning in a ginseng garden in Wisconsin (fig. 24). All the plants in a circular area a rod in diameter were killed or injured, the tops turning brown, wilting, and dying. In many cases the fibrous roots were completely stripped from the main root. Only 10 per cent of the roots developed tops the following season, and these appeared to be weak and sickly. However, injury to ginseng from lightning seems to be rare, the dying of plants in circular areas in the beds being due usually to some fungous disease.

RELATION OF FERTILIZERS TO DISEASE.

Lime and wood ashes.—From the natural acid character of the forest soil it would appear that lime or wood ashes are of doubtful value to ginseng grown under cultivation. It was found that wherever lime was used, especially on seedling beds, injury followed. This was due to the fact that an alkaline soil favors the development of the Thielavia fungus, and in view of this the use of lime or ashes on ginseng beds should be avoided.

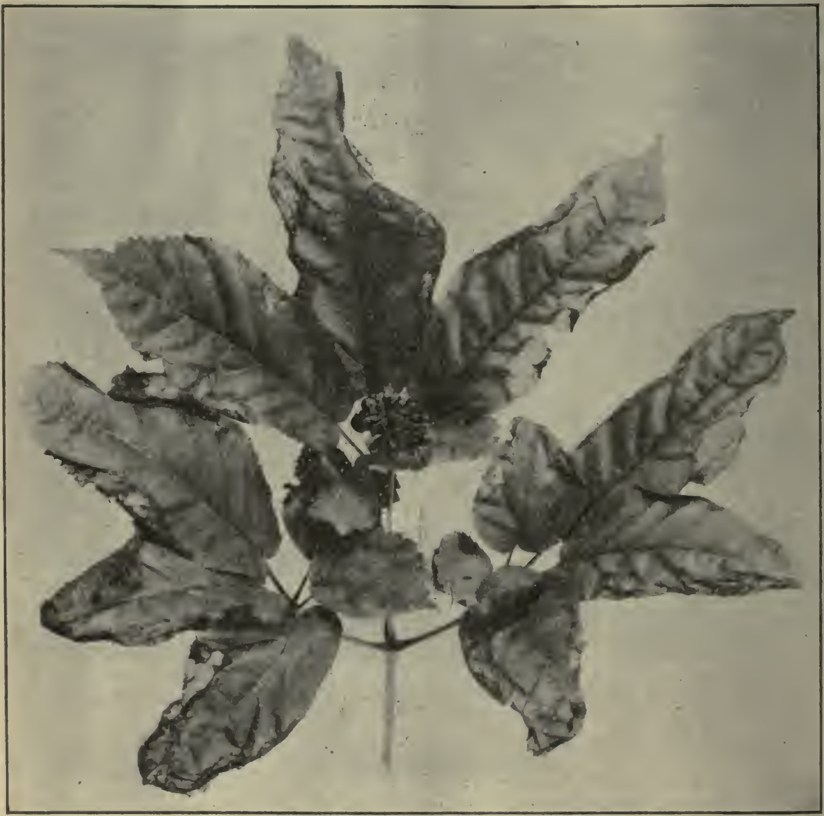

FIG. 25.—Ginseng leaves showing injury caused by an excess of nitrogenous fertilizers.

Acid phosphate.—The effect of acid phosphate is entirely opposite to that of lime. Many growers make a practice of applying acid phosphate each fall before putting on the mulch. From 1,000 to 2,000 pounds per acre have given good results, but the quantity that should be applied varies according to the condition of the soil.

Nitrogenous fertilizers.—Fertilizers containing nitrogen are of value when not used to excess. A heavy application of nitrate of soda or of barnyard manure may cause injury to the leaf (fig. 25).

SPRAYING.

Spraying is the application of substances in water to the surface of the plant to protect it from the attacks of parasitic fungi or insects. It is not a cure, nor can it be used to protect the portions of the plant below the surface of the ground.

Bordeaux mixture.—Bordeaux mixture, either homemade or commercial, has been found to be the most reliable spray for ginseng. The homemade Bordeaux mixture is made of copper sulphate (blue vitriol) and good hydrated or stone lime. The strength recommended for use in spraying ginseng is 3–3–50; that is, 3 pounds of copper sulphate, 3 pounds of stone lime, and 50 gallons of water. To prepare such a solution, dissolve 6 pounds of copper sulphate in 50 gallons of water by suspending the crystals in a sack just beneath the surface of the water, slake 6 pounds of stone lime with hot water, and when completely slaked add enough water to make 50 gallons of lime milk. When ready to spray, mix equal parts of the two solutions, taking care to stir both. Never pour the two solutions together until ready to apply. To remove particles that might clog the nozzle, it is well to strain the mixture as it goes into the sprayer. An insecticide, such as arsenate of lead, 2 pounds to 50 gallons of Bordeaux mixture, may be added to this mixture.

Before applying Bordeaux mixture it is absolutely necessary to use lime enough to act on all the blue vitriol. This may be determined by what is known as the ferrocyanid test. An ounce of the yellow prussiate of potash is dissolved in a pint of water. When placed in a bottle this will keep indefinitely. Lime should be added to the copper-sulphate solution until the prussiate of potash will not turn brown when dropped from the bottle into the mixture. Then add an extra gallon or so of the lime milk. A slight excess of the lime will do no harm and will insure against spray injury from free copper.

Spraying should be begun as soon as the plants come up, but applications just before freezing should be avoided. The frequency of applications depends on the growth of the plants and on the disease for which they are being sprayed. All growing parts of the plant as they become exposed should be covered with the spray. The spray should be applied just preceding rains, as the fungus spores germinate and infect the plants during rains. The plants should not be sprayed when in blossom, as spraying has a tendency to prevent the setting of the berries. Leaves, stems, and seed heads should be completely covered on all sides with the spray. Thorough work can best be done with a nozzle which gives a fine mist and with a pressure of not less than 50 pounds, or, better, 100 to 150 pounds.

Lime-sulphur.—Little success has followed the use of lime-sulphur for ginseng diseases. If used at all, it should not be applied during the early stages of the growth of the plants.

SOIL DISINFECTION.

Because of the fact that the disease-producing organisms gradually accumulate in the soil, diseases are more prevalent in soils on which ginseng has previously been grown. Before using a soil in which this crop has been grown it should be sterilized with steam or disinfected with formaldehyde, so as to destroy as many of the disease organisms as possible.

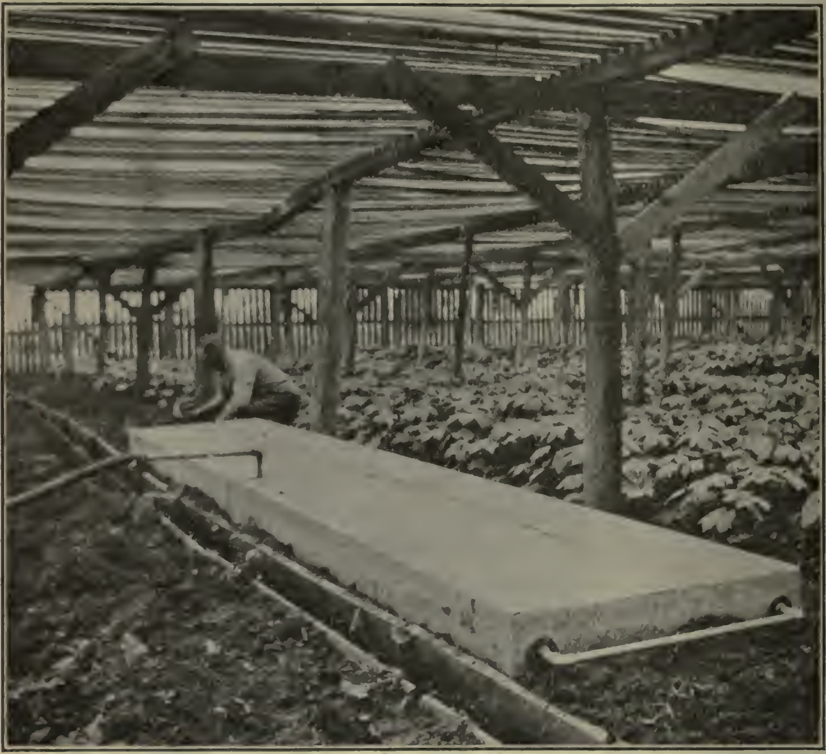

FIG. 26.—Inverted pan for sterilizing the soil with steam.

Steam sterilization.—The steaming should be done very early in the spring or in the fall. In addition to killing the fungi it also kills to a large extent the weed seeds. The labor of weeding thus saved is enough to pay for the cost of treatment. It also changes the physical texture of the soil, making it more suitable for root development, and considerable plant food is made directly available to the plant. As stated in Bulletin No. 250 of the Bureau of Plant Industry, the inverted-pan method (fig. 26) devised by Mr. A. D. Shamel, of this bureau,[1] appears to be the most practicable for ginseng beds. "The apparatus for ginseng beds of the usual width should consist of a galvanized-iron pan, 4 by 10 feet and 6 inches deep, which is inverted over the soil to be sterilized, the steam being admitted through a steam hose connection in the end or side of the pan. The sharp edges of the pan which are forced down into the soil prevent the escape of the steam. The pan is fitted with handles for moving and should weigh not more than 400 pounds. The soil is prepared as for planting. All fertilizers are applied and worked in as desired. A few potatoes are buried at a depth of about a foot, to gauge the degree of heat attained. These should be cooked when sterilization is completed. The steam should be kept at as high a pressure as possible, 80 to 100 pounds." The treatment should be continued for 20 minutes to 1 hour, depending on the pressure of the steam and the character of the soil.

Formaldehyde disinfection.—Formaldehyde has been used again and again by various growers with very good results (see fig. 21). The treatment should be undertaken in the autumn, but in some cases it may be given in the spring. All the roots should be removed from the beds and the soil thoroughly worked up. The formaldehyde (40 per cent solution) is diluted and is applied by one man with a hose or a large watering pot, while another man spades over the soil. The soil should be as dry as possible, but if wet the proportion of water should be reduced accordingly. The grower should first test how much water each square foot of soil will hold, and then dilute the formaldehyde so that 1 gallon of the strong or 40 per cent solution will be distributed over 50 square feet of soil. The soil should not be worked after treatment until the excess of water is well drained off. As soon as it will work without puddling it should be again thrown up loosely, to permit the evaporation of the formaldehyde. Ten days to two weeks after treatment, several respadings having been made, the beds should be in condition for planting.

DRAINAGE OF GINSENG BEDS.[2]

Artificial drainage is a necessity in the ginseng bed, not only from the standpoint of culture, but also as regards diseases, which, as has been shown, are favored by excess of water in the soil. In the removal of such water good results have been obtained from the use of draintile in the ginseng bed. It is impossible to give definite directions for a system of drainage, as the amount necessary varies with the character of the soil and the rainfall. Generally speaking, 3-inch tiles should be placed 6 to 8 feet apart and 3 to 4 feet deep in sand and gravel and 1½ to 2 feet deep in clay.

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[1] One of the writers has added an attachment to the steam-inlet tube in the form of a wing steam distributor, and by means of this device there is a uniform distribution of the steam to all parts of the pan.

[2] For detailed information regarding tile drainage, see Farmers' Bulletin 524, United States Department of Agriculture.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO SOME DISEASES OF PLANTS.

AVAILABLE FOR FREE DISTRIBUTION.

Diseases of Cabbage and Related Crops and Their Control. (Farmers' Bulletin 488.)

Two Dangerous Imported Plant Diseases. (Farmers' Bulletin 489.)

Leaf-Spot, a Disease of the Sugar Beet. (Farmers' Bulletin 618.)

The Control of Root-Knot. (Farmers' Bulletin 648.)

Potato Wilt, Leaf-Roll, and Related Diseases. (Department Bulletin 64.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

A Spot Disease of Cauliflower. (Bureau of Plant Industry Bulletin 225.) Price, 5 cents.

A Plant-Disease Survey in the Vicinity of San Antonio, Tex. (Bureau of Plant Industry Bulletin 226.) Price, 20 cents.

Investigations of the Potato Fungus Phytophthora infestans. (Bureau of Plant Industry Bulletin 245.) Price, 30 cents.

The Diseases of Gingseng and Their Control. (Bureau of Plant Industry Bulletin 250.) Price, 15 cents.

The Structure and Development of Crown Gall: A Plant Cancer. (Bureau of Plant Industry Bulletin 255.) Price, 50 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 737 JUNE 26, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE CLOVER LEAFHOPPER[1] AND ITS CONTROL IN THE CENTRAL STATES.

By EDMUND H. GIBSON,

Scientific Assistant, Cereal and Forage Insect Investigations.

INTRODUCTION.

The control of the injurious clover leafhopper (fig. 1) is a comparatively simple task to one acquainted with the habits of the insect.

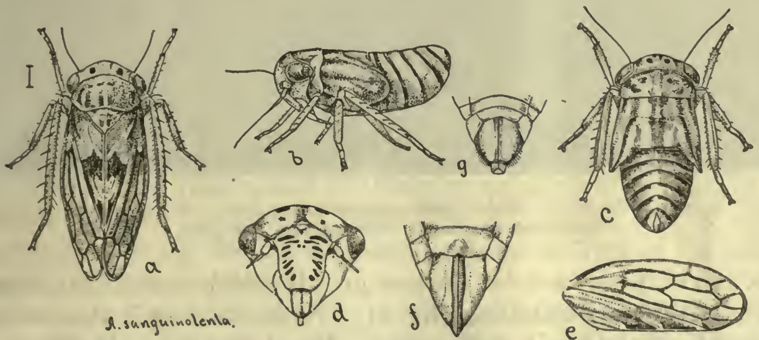

FIG. 1.—The clover leafhopper (*Agallia sanguinolenta*) : *a*, Adult ; *b*, nymph, side view ; *c*, nymph, dorsal view ; *d*, face ; *e*, elytron ; *f*, female genitalia ; *g*, male genitalia. All enlarged. (After Osborn and Ball.)

The injuries caused by this insect, as is the case with many other leafhoppers, are often overlooked because of the minute size of the pest, and the apparent injury is too frequently attributed to such causes as poor soil and climatic conditions.

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[1] *Agallia sanguinolenta* Prov. ; suborder Homoptera, family Bythoscopidae.

NOTE.—It is the purpose of this bulletin to set forth such facts as will familiarize the farmer with the various stages in the development of the clover leafhopper, its habits, and mode of attack, together with detailed information as to the control of outbreaks in alfalfa and clover fields.

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IMPORTANCE OF THE DAMAGE.

Each year this leafhopper, by lessening the vitality of its food plants, occasions more or less damage over its entire range of distribution, causing a positive, although not easily estimated, decrease in the clover and alfalfa hay crops of the country. Continued attacks often result in the loss of a considerable percentage of a single cutting; especially is this true in some of the central States. The leafhopper causes the greatest damage during the spring and early summer months, as the foliage is then most succulent and the tissues very tender, enabling even the immature leafhoppers readily to pierce the skin of leaf and stem and suck the juices. The incessant drain from concentrated attacks causes the clover plants to wither, and although they may not die, the new growth which is put forth is very apt to be thin and spindling (fig. 2). With alfalfa it is the first two crops which appear to suffer most. The drain upon alfalfa plants does not show as markedly as with clover, especially during a drought, since the alfalfa roots go deeper into the ground and the plant is better able to withstand adverse conditions.

FIG. 2.—A spot in an alfalfa field showing the spindling growth of the plants, caused by continued attacks of leafhoppers. (Original.)

DESCRIPTION OF THE INSECT CAUSING THE DAMAGE.

In many localities these leafhoppers are commonly known as "flies," but in reality they resemble flies only in having wings, and because they are about the size of many small flies seen in the fields. The adult or parent insects (fig. 1, *a*) are light gray in color, but have numerous dark markings which give them a mottled appearance. They are about one-eighth of an inch in length and half as wide.

The face (fig. 1, *d*) is triangular and is marked with short black lines. The two small, round, dark spots on the upper side of the head distinguish the clover leafhopper from many others frequently observed in alfalfa and clover fields. The nymphs, or young, resemble the adults in form but lack wings. In color they are creamy white with heavy dark spots and bands. The eggs are white and very small. To the farmer, leafhoppers will be distinguished from other insects not so much by their form and markings as by their habit of jumping, their quick movements, and their minute size. The manner in which they jump from plant to plant is much like that of grasshoppers.

WHERE THE LEAFHOPPER OCCURS.

The clover leafhopper is distributed generally throughout the United States, records showing its occurrence in every section of the country. Its range also includes southern Canada and Mexico.

THE INJURY, AND HOW IT IS PRODUCED.

The primary injury is produced by the direct feeding of the leafhoppers. The single tiny feeding puncture is itself inconsequential, and injury results only when a great number of leafhoppers attack the same plant. As many as 600 have been counted upon one plant. The early stages of injury are indicated by a yellowing of the tissue around the feeding punctures. These spots gradually enlarge and become more pronounced, and the plants take on a sickly condition which results in the curling up of the leaflets and the final wilting of the foliage. The leafhoppers have been noted to puncture the flower buds and petals, and in this way to cause a decrease in the amount of seed produced. Upon grains, grasses, and grasslike plants most of the feeding is done along the midribs of the blades, causing the latter to shrivel.

A second form of injury is produced by the forcing of the eggs into the stem and leaf tissue by the adult female. This causes a distortion of the surrounding tissue and often results in a gall-like formation.

PLANTS ATTACKED.

The principal plants attacked are those of the bean family, including alfalfa, clover, cowpea, and vetch; although the species is common in meadow and pasture lands and feeds on a number of cultivated as well as native grasses. Adults have been captured in wheat, rye, and barley fields, but in all probability they migrated there from near-by grasslands or clover fields. The frequent occurrence of this leafhopper in wheat in the eastern half of the United States is very probably due to the practice of planting wheat before the clover comes up in the spring. In some of the western States it has at times been considered a pest to sugar-beet plants.

As plants of one family constitute the principal food plants of this leafhopper, it is to be assumed that it has not the power of readily adapting itself to changes of food plants. The fact that the clover leafhopper occurs in grass and pasture lands and also feeds upon grain plants in the absence of clover or alfalfa during the winter and spring merely indicates that when its favorite plants are not obtainable it is forced to seek food elsewhere.

STAGES AND LIFE CYCLE OF THE LEAFHOPPER.

There are three general stages in the development and growth of all leafhoppers, namely, egg, nymph or immature stage, and adult. The adult female places her eggs in stems and leaves, these hatching in from 5 to 12 days during the summer months in the latitude of southern Illinois. The nymphs develop and increase in size by shedding their skins through a series of five molts, becoming adults after the last molt. The nymphal stage in the same latitude ranges from 18 to 35 days, with an average of 25 days.

NUMBER OF GENERATIONS IN A YEAR.

The number of generations of the leafhopper produced annually in a given locality varies from year to year, depending on weather conditions, and it also varies in different latitudes and climates. For southern Missouri and northern Arkansas there are usually three distinct broods, covering approximately (1) April and May, (2) June and July, and (3) August and September. Farther south or under subtropical conditions it is probable that there are four or more.

HOW THE LEAFHOPPER PASSES THE WINTER.

In the Northern States the clover leafhopper hibernates in the adult stage, at the base of clumps of grass and weeds and under dried leaves and trash. Throughout the Central and Southern States it could hardly be said to hibernate; instead, the adults merely keep in hiding and under cover during cold weather, coming out on warm days to bask in the sun and feed upon such green foliage as can be found. In Missouri, for example, the adult insects have been observed feeding upon wheat during January and February, but not in any abundance. Nymphs can not long survive cold weather, and it is not probable that eggs survive over winter. In the extreme Southwest, where conditions are radically different, the leafhopper is active throughout the entire year.

HABITS OF THE ADULT AND YOUNG LEAFHOPPERS.

The adults are quick of movement and jump from plant to plant when disturbed. When strong winds prevail they remain in hiding, as they seem to dislike windy weather. Their most characteristic habit is that of congregating in great numbers on one plant, frequently to such an extent that they crowd one another. This is what causes the concentrated attacks in "spots" throughout a field. The clover leafhopper does not seem to seek shady or damp places, rather preferring the heat of the midday sun.

The nymphs are much less active than the adults and are not easily disturbed. When one brushes against the plants they cling fast to the stems and leaves instead of jumping to another plant. Like the adults, they have the habit of crowding together along a stem or upon a leaf.

ENEMIES OF THE LEAFHOPPER.

The insect enemies of the clover leafhopper seem to be few. Birds appear to be the most important enemies, and among the common species known to eat various species of leafhoppers in numbers are the nuthatches, yellow warbler, blue-headed vireo, long-billed marsh wren, nighthawk, phoebe, tree swallow, cliff swallow, bank swallow, and chickadee. In addition to these, over a hundred species of wild birds are known to feed upon leafhoppers. These birds should receive protection at the hands of the farmer. Chickens, turkeys, and guinea fowl, when allowed to run in the clover and alfalfa fields, eat great numbers of both nymphs and adults. Many adults have been observed in spider webs, and it is very likely that in their jumping from plant to plant numbers are caught in the webs.

CONTROL OF THE LEAFHOPPER.

BURNING OF RUBBISH AND WASTE VEGETATION.

The burning of rubbish and vegetation during the winter months in waste places such as on ditch banks, on terraces used in certain sections for the prevention of erosion, and along fence rows and roadsides will do much to prevent the species from becoming destructive the following spring and summer, for if this is done, their winter quarters will be destroyed and great numbers of the leafhoppers, as well as many other hibernating insects, will be killed.

CLOSE CUTTING OR PASTURING OF GRASSLANDS; EARLY CUTTING OF ALFALFA.

Close cutting or pasturing of grasslands is recommended while the leafhopper is in the adult stage. Cutting the alfalfa crop from a week to ten days earlier than usual will often have the desired effect of checking the species, and is advised where there is evidence that the leafhoppers are causing sufficient injury to justify the risk of damage through premature cutting.

USE OF THE HOPPERDOZER.

For direct control the hopperdozer is recommended. Any hopperdozer which has been constructed to capture grasshoppers will suffice, but a much lighter and less expensive one can be made by stretching canvas over a light wooden frame. The diagram, figure 3, shows how it can be made. It is of such light weight that in pulling it over alfalfa and clover the plants are not injured. In pulling this hopperdozer through fields which are free from stones runners will not be necessary. It is drawn by two horses, one hitched at either end of the two-by-four, and is dragged over the crop, covering as much acreage in the same length of time as is gone over by a cutting or mowing machine. Figures 4 and 5 show the front and back of the hopperdozer ready to be drawn through an alfalfa field. It is to be regretted that in figure 4 the bottom of the hopperdozer is not visible. Heavy canvas is stretched and tacked or nailed over the inside of the frame, covering bottom, back, and sides.

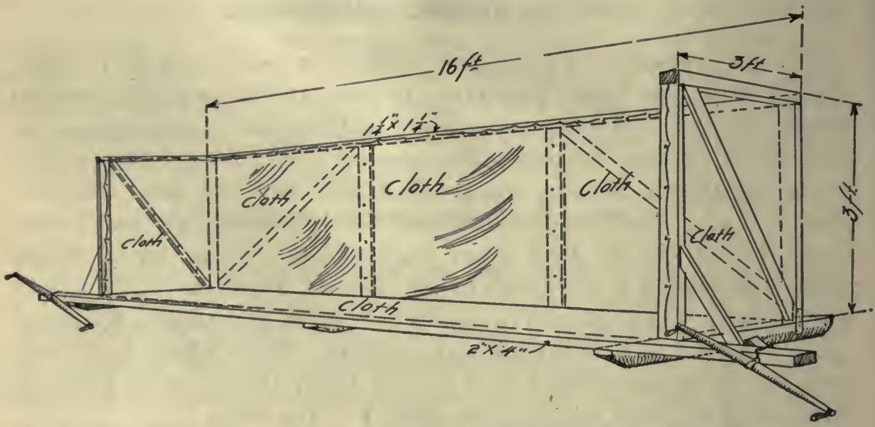

FIG. 3.—Construction of frame of hopperdozer for destruction of leafhoppers, over which canvas is stretched. (Original.)

Over the canvas, on the inside, is applied a thin coat of a sticky substance made of tree tanglefoot which has been thinned with a cheap commercial grade of castor oil at the rate of 1 pound of tanglefoot to one-fourth pint of castor oil. This can be spread on the canvas with a paddle or shingle. The leafhoppers and other insects alighting on the sticky surface are held fast. These insects, together with dried leaves which will adhere to the canvas, can be scraped off whenever necessary and another coating of tanglefoot applied. One coating should be sufficient for 5 acres.

The cost of the hopperdozer should be little more than the price of the canvas, as odd pieces of lumber can be used in construction.

Tree tanglefoot can be obtained in 10-pound cans at $1.65 per can, and the castor oil at a maximum cost of 30 cents per quart. Without considering labor, the cost of this control measure should not be more than $4 for 100 acres, or at the rate of 4 cents per acre.

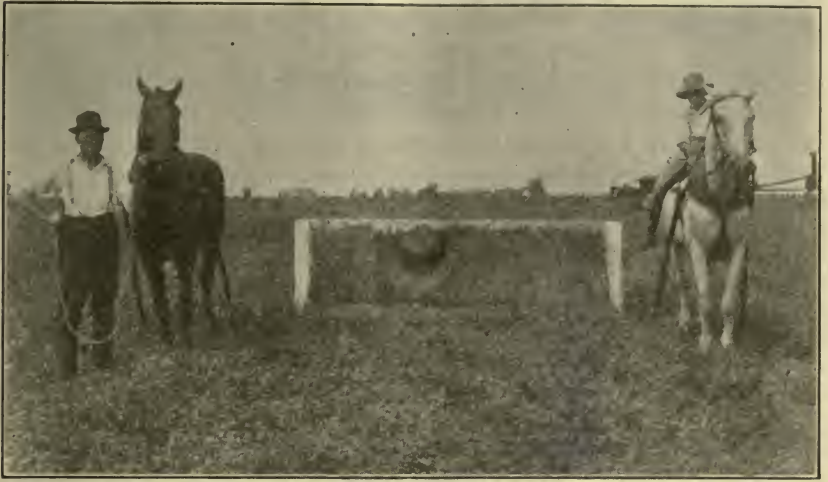

FIG. 4.—Front view of hopperdozer for destruction of leafhoppers as it is being drawn through an alfalfa field. (Original.)

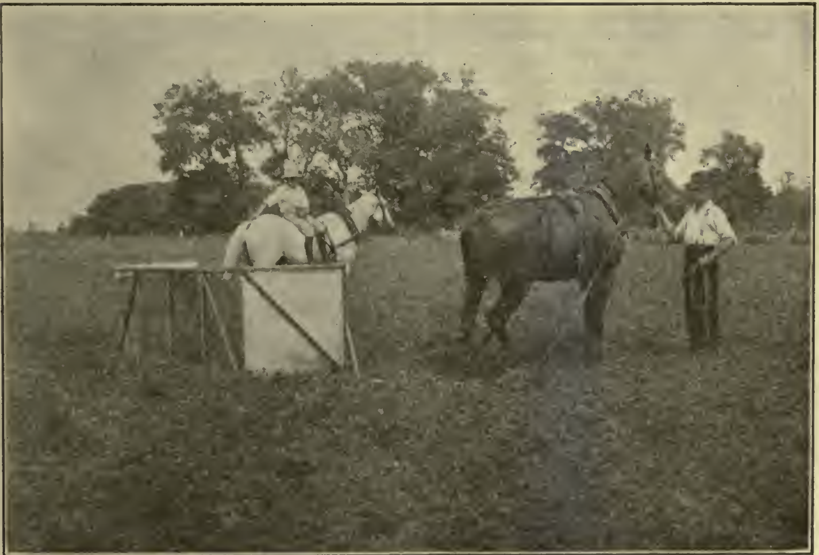

FIG. 5.—Side and back view of the hopperdozer for destruction of leafhoppers. The horses are hitched to the projecting ends of the two-by-four. (Original.)

This method is practical in fields covering several hundred acres as well as in small fields. Other sticky substances such as cheap sorghum and corn sirup have been tried in place of tree tanglefoot but with much less success, as they dry out too quickly; this necessitates more frequent applications and thus renders them more expensive.

The hopperdozer should be drawn through the alfalfa and clover fields at the time when the crop is about half grown. It can, however, be drawn at any time without injuring the plants, although it is not advisable to do so within five days of the time the crop is to be cut. If the adults are numerous at the time of cutting, the hopperdozer should follow the rake.

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 738 JUNE 15, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

CEREAL CROPS IN THE PANHANDLE OF TEXAS.

By JOHN F. ROSS, *Farm Superintendent, Office of Cereal Investigations.*

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INTRODUCTION.

There is a growing demand for information regarding crops that are adapted to the Panhandle of Texas. This demand is indicated by the large number of letters of inquiry received. Many of these inquiries come from people who already are living in the Panhandle. Others are from nonresidents who own land there, and many come from persons who are looking for a place to acquire a home. They need definite facts, so far as these are available, on which they can make decisions and take action. They need the results of the experiments that have been conducted in that section, plainly and briefly told.

It is the aim of this paper to tell the farmer, landowner, or prospective settler what has been learned about the cereal crops through cereal investigations in the Texas Panhandle.

The suggestions made herein are not considered final. They are the conclusions drawn from experiments conducted and observations made from 1903 to date. It is hoped that they will form at least a working basis for farming operations in the section discussed.

The points at which experiments have been conducted by the United States Department of Agriculture are Amarillo, Channing, Dalhart, and Chillicothe, Tex. A view of the farmstead of the Amarillo Cereal Field Station is shown in figure 1.

Amarillo is a little northwest of the center of the Texas Panhandle. Channing is about 50 miles and Dalhart 83 miles northwest, while Chillicothe is about 150 miles southeast of Amarillo. The most complete series of experiments has been conducted at Amarillo.

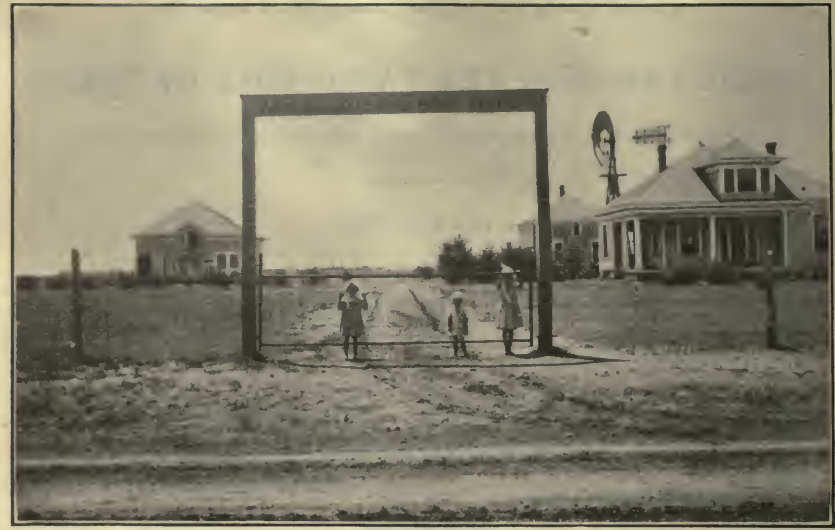

FIG. 1.—Farmstead of the Amarillo Cereal Field Station in July, 1914, showing the buildings and the black-locust grove.

The crops that are discussed in this paper are wheat, emmer, spelt, rye, oats, barley, and proso. Brief mention is made also of the grain sorghums and corn, which are discussed more fully in other available bulletins.

THE PANHANDLE.

The Panhandle is that part of northwestern Texas which extends northward from the main body of the State. In common practice this term is usually applied to the entire northwestern part of the State, above the cap rock, including the so-called Staked Plains. The word is here used in the broader sense. Figure 2 is a sketch map of this region. The results given in these pages are applicable to all the district lying above the level of 2,000 feet and to a considerable extent to lower elevations. They apply largely also to adjacent similar areas in New Mexico, Colorado, Oklahoma, and Kansas.

TOPOGRAPHY.

The western two-thirds of this district is a high and nearly level table-land with an average altitude somewhat less than 4,000 feet and with a rather uniform slope to the east and southeast. The highest elevation reached is about 4,800 feet in the extreme northwest, while the southeastern border, roughly the line of the cap rock, has an altitude of only 1,500 to 2,000 feet. East of the nearly

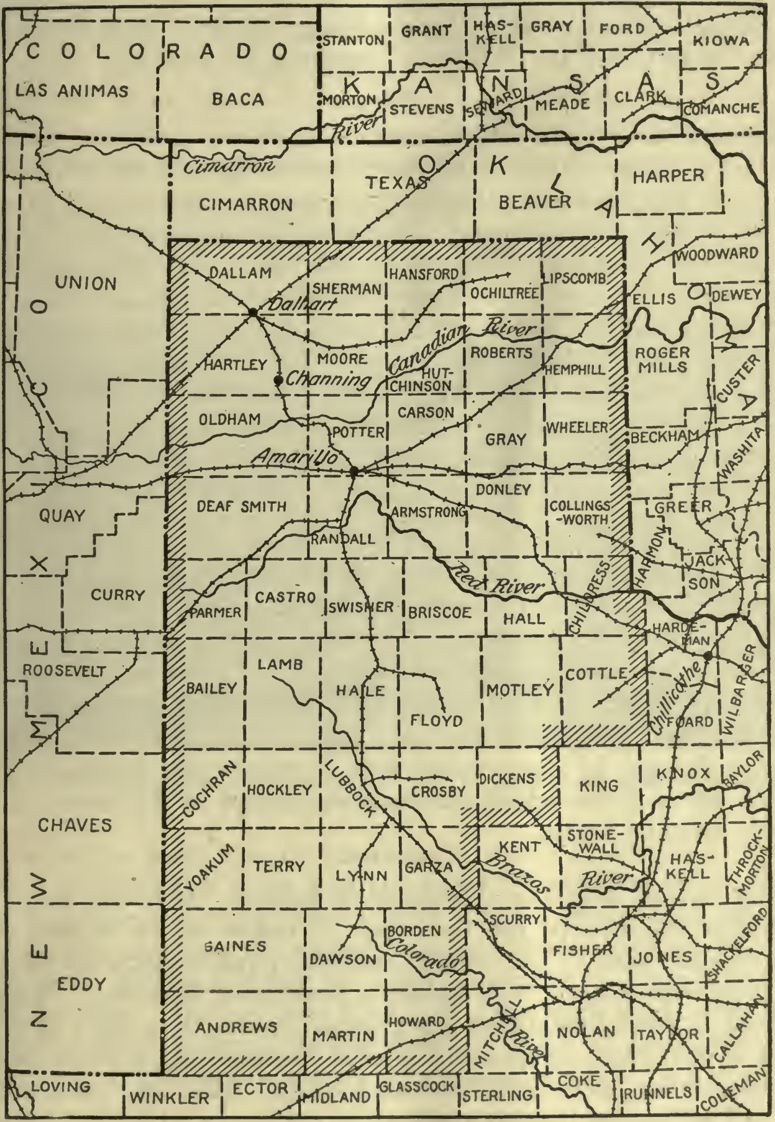

FIG. 2.—Sketch map of the Panhandle section of Texas and the surrounding country. The Panhandle section as discussed in this bulletin is indicated by the shaded boundary.

level high plains is a rough, broken area where the cap rock is worn through and erosion is more rapid. Still farther eastward, below the cap rock, the country is rolling.

Drainage is eastward through the tributaries of several rivers. In the high plains above the cap rock, these streams tend to form canyons, the most notable of these being Paladora Creek, extending from Canyon, in Randall County, eastward for 60 miles.

SOIL.

The soil varies from a light sand in some parts to a heavy clay or adobe in others. Much of the northwestern part of the Panhandle north of the Canadian River is quite sandy. Sandy land is also found in Bailey County and along the Canadian and Red Rivers. Taking the Panhandle as a whole, the heavy clay-loam soils predominate. The sandy soil is covered with bunch grasses, while the clay soil is covered with buffalo, curly-mesquite, and blue-grama grasses. These soils are quite fertile, but are lacking in humus, owing to the scanty growth of native vegetation. This lack of humus lessens the capacity of the soil to absorb the moisture which falls upon it. The heavy clays and clay loams become compact and bake readily after heavy rains.

CLIMATE.

The climate of the Texas Panhandle is quite similar to that found generally in the Great Plains. The rainfall is limited and irregular. It is not equally distributed either as to time or place. Much of the rain comes in heavy showers and the loss due to run-off is sometimes very great. The air is quite dry. There is an unusual amount of wind, and evaporation is very high. There are frequent and sudden changes in temperature, both in winter and summer. The nights are cool throughout the summer, except in the lowest parts of the east and south.

RAINFALL.

The rainfall over the Panhandle is limited. It varies from 15 inches in the western part to about 25 inches in the eastern and southeastern parts. The average annual rainfall at Amarillo for the 24 years from 1892 to 1915, inclusive, has been 21.21 inches. Three-fourths of this comes during the growing season, from April to September, inclusive. The seasonal rainfall is sometimes very irregular in its distribution, as to both time and locality. The larger part of the rainfall for one month may come at its beginning, while that for the next month may not come until the latter part. Thus a severe drought, 4 to 6 weeks long, could have occurred between the two rainy spells, although the rainfall for the two months was about normal.

Many of the rains during the summer are very local in extent. Heavy showers may occur at different points, with stretches of almost no rainfall between. To illustrate the variation in rainfall the following example is given: On July 4, 1914, local showers fell in many places in the Panhandle. The rainfall at the Weather Bureau station in Amarillo was 1.71 inches, while at the Cereal Field Station, 2½ miles distant, it was only 0.22 inch. Thus the rainfall at the Weather Bureau station on that day was nearly eight times as much as that at the field station. Differences of this kind may occur, and frequently do, in any part of the Panhandle.

The rain often falls so rapidly for a short time that much of the water is unable to soak into the soil. This is the case on heavy clay and adobe soils, and on such soils there is often a heavy run-off. For this reason a heavy rain is sometimes of very little benefit to crops. These beating rains make matters worse by puddling the surface, which afterward bakes into a hard crust. When this happens shortly after seeding, the young plants are unable to break through this crust. Figure 3 shows the run-off after one of these torrential summer rains. During these heavy rains the more sandy soils take in the moisture nearly as fast as it falls. They do not puddle and afterwards bake like the heavy clay and adobe soils.

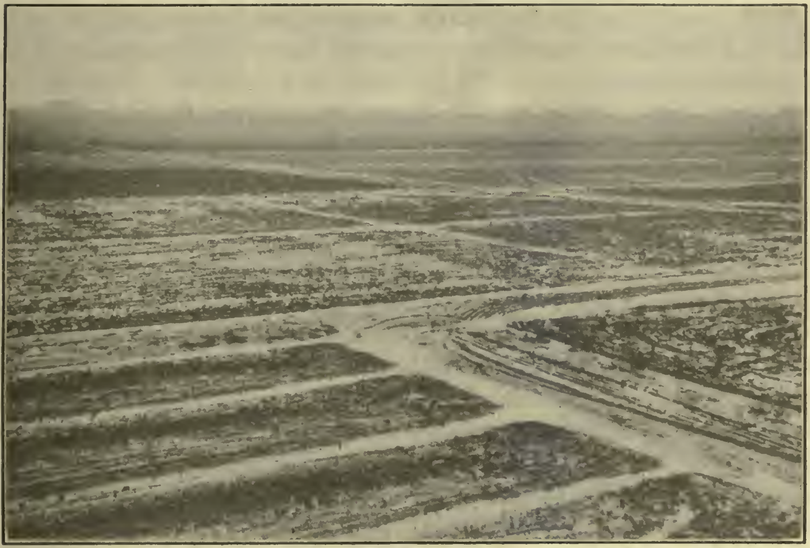

FIG. 3.—View of a part of the Amarillo Cereal Field Station on August 15, 1907, showing the enormous run-off after a torrential summer rain.

HUMIDITY.

On the average, the air over the Panhandle is very dry. It therefore takes up moisture wherever it can get it, from the soil and from the plants themselves. The plants are hindered in their growth and may even be killed. In extreme instances, where the plants are actually killed, the moisture is taken from the plant above the ground faster than it can be supplied by the roots.

WIND.

The Texas Panhandle is very windy during the whole year, the general direction of the wind being from the southwest. The wind blows so much from this one direction that trees are bent toward the northeast. Quantities of soil are moved by the wind when it is high. Soil blowing, especially on the light clay and sandy soils, may do much damage to crops. The winds also cause loss of grains, such as oats and proso, by shattering at the time of ripening. Winds are general over the entire Panhandle country, but have a greater sweep over the high level plains than over the more rolling section in the east and southeast.

The average hourly wind velocity, as shown by the Weather Bureau records at Amarillo, Tex., for the years 1905 to 1915, inclusive, is 11.5 miles. An hourly velocity of 40 miles is reached several times each year, and at times the velocity is much higher. The highest recorded velocity at Amarillo was 84 miles, on April 5, 1895.

EVAPORATION.

The evaporation of moisture from the ground and from the crops themselves is very great. This is caused by the dry air and continuous wind. In periods of drought and high winds it reaches a maximum. The average evaporation from a free water surface for the growing season, April 1 to September 30, at the Amarillo Cereal Field Station for the years 1907 to 1915, inclusive, was 53.2 inches. This rate of evaporation would hold generally for all the Texas Panhandle on the high plains. In the more broken parts to the east and southeast and at the lower elevations, the evaporation probably is less. The evaporation from the soil can not be given in definite quantities, but where the winds are high and dry it is very great.

TEMPERATURE.

The changes in temperature in the Panhandle are more violent than in sections to the eastward. The highest temperatures are much lower than might be expected when the altitude is not taken into consideration. In summer the days are hot and the nights cool. These cool nights retard the growth of many of the crops. In winter severe cold weather occurs, but there are many days between the cold spells when field work can be done. In spring and fall changes in temperature from very warm to very cold occur quite often.

The maximum temperature in summer very rarely reaches 100° F., while the minimum in winter almost as rarely reaches zero. At the

Weather Bureau station at Amarillo the highest recorded temperature is 105° F., and the lowest −15° F. The average yearly temperature is 56° F. The difference between the averages of the highest and the lowest daily temperatures, however, averages only about 24 degrees F. throughout the year over the whole Panhandle.

The average date of the last killing frost in spring at Amarillo is April 19, and that for the first killing frost in the fall is October 29. This gives an average frost-free period of 195 days. In the extreme northwestern part of the Panhandle this frost-free period is shortened about 10 days, while in the southeastern portion it is lengthened about as much.

FARMING IN THE PANHANDLE.

Farming in the Texas Panhandle was almost an unknown thing 20 years ago. The land was occupied by immense cattle ranches and was used only for grazing purposes. The short but nutritious grasses furnished both summer and winter pasturage. Each animal required from 15 to 40 acres of this grazing land, depending on the nature of the grass cover, the character of the season, and the time of year. Finally, the range became overstocked, and as a result heavy losses occurred during the seasons of drought and in severe winters. This created a need for feed crops suitable for growing on the Plains. At the same time the demand for new, cheap lands for homes and crop production was increasing. The large ranches were divided and portions sold for farms.

Within the last 10 years the settlement of this Plains country has made steady progress. There have been several dry years during this period, and consequently many failures. These failures have greatly stimulated the growing of crops that have been found adapted to the Panhandle country. The cereal experiments conducted at different points have been of great value in determining what crops and crop varieties are adapted to this high Plains country. A view of the first farm on which experiments were conducted at Amarillo is shown in figure 4.

When the change from cattle ranches to crop farming first began, the tendency was to grow crops only and to neglect stock. This is true still to a large extent, but mixed farming, the raising of both stock and crops, is rapidly gaining favor. Feed crops, both grain and forage, are successfully grown. Large markets are distant, and many communities still far from the railroad find transportation difficult. Mixed farming is the logical solution of these problems and is the only profitable type of farming under Panhandle conditions.

The small grains, therefore, are of minor importance here. Some have their place, however, in the farming scheme, and a knowledge of which ones to grow and how to grow them is important.

HOW TO GROW SMALL GRAINS.

The growing of winter grains, on the whole, has been more successful than the growing of spring grains in the Texas Panhandle. Winter wheat is the most important of the winter grains, while spring oats is the only spring small grain that has given even fairly profitable yields. More wheat than oats is grown in the Panhandle. The winter-wheat crop is of much more importance than spring oats as a money crop. Both these crops can be used to advantage in a general farming system.

PREPARATION OF LAND FOR WINTER GRAINS.

Land that is to be used for the growing of winter grains should be prepared as early in the summer as possible. It should be plowed to a depth of at least 6 inches. This plowing should be well done; all the land should be turned. Weeds should not be allowed to get a start. In the work of keeping down weeds, care must be taken not to fine the surface soil too much on either light or heavy soils. Land that is made fine on the surface will blow more than if left somewhat rough. Where land is prepared just before seeding, better results are obtained from disking than from plowing. This late preparation of land, however, is not good farm practice.

FIG. 4.—The first experiment farm at Amarillo, Tex., on June 19, 1908, showing small grains in shock. A dairy farm is seen in the middle background.

Increased yields are obtained from alternating summer fallow and crops, but the increase is not large enough to pay for the extra work of maintaining the fallow.

It usually is impossible to follow most sorghum crops with winter grains. The sorgos and kafirs grow late in the fall and leave the soil dry. It therefore is better to grow some leguminous crop like cowpeas the next year after the grain sorghums have been grown. When late fall and winter rains have been abundant, spring grains may follow grain sorghums.

PREPARATION OF LAND FOR SPRING GRAINS.

In preparing land for spring small grains following another small-grain crop, fall plowing is better than spring plowing. Furrowing with a lister and leaving the ground rough during the winter is practically as good as plowing for spring oats and a little better than plowing for spring wheat. The cheapest preparation for oats is disking after corn; but, as corn is not a good crop to grow in much of the Panhandle, this method rarely can be used. Where small grains follow sorghums, plowing usually is necessary because of the drier ground and heavy stubble. The same care should be taken in doing the plowing for spring grains as for winter grains. Land that has been fall plowed will need disking in the spring before seeding if the surface soil has crusted badly from winter snow or rain. If this crust is not too heavy the drill will break it sufficiently in seeding.

PREPARATION OF SEED.

GOOD SEED.

It is very important that good seed be used. It should be pure as to variety, free from weed seed and other impurities, well matured, of strong vitality, and home grown as far as possible. In all tests with seed from various localities compared with home-grown seed, the latter has always given the best average yield. The farmer is urged to select his own seed and to keep it clean and pure. Running the seed through a fanning mill once is recommended, to remove weed seed, trash, and light, small kernels.

TREATMENT FOR SMUTS.

There is considerable loss from smut in small-grain crops every year. The larger part of this loss is easily prevented by treating the seed before sowing with a formaldehyde solution composed of 1 pound of 40 per cent commercial formaldehyde to 40 gallons of water. Either of the methods described below is effective for the common bunt or stinking smut of wheat, the loose smut of oats, and the covered smut of barley.

(1) Spread the grain to be treated upon a clean floor or upon a tarpaulin spread thereon and sprinkle the formaldehyde solution over the grain. The grain should be stirred thoroughly while being sprinkled, and the process should be continued until every kernel is wet. Then cover the grain with a canvas or some other heavy material and allow it to lie one hour. It should then be uncovered and stirred occasionally until dry. It is then ready for seeding.

(2) Prepare the formaldehyde solution in barrels. Put the grain to be treated in burlap sacks. Do not fill the sacks too full. Immerse the sacks in the solution for 10 minutes; then hang them up to drain and dry. The sacks should be shaken occasionally, to hurry the drying process.

The loose smuts of wheat and barley may be controlled by a different method, the modified hot-water treatment. This consists in soaking the seed in cold water for five hours. Wheat is then soaked in hot water at 54° C. for 10 minutes and barley at 52° for 15 minutes. This treatment for loose smut is more difficult to perform than the formaldehyde treatment. Great care should be taken to have the temperature of the water just right.[1]

SMALL-GRAIN CROPS.

Small-grain crops, though of minor importance when compared with the grain sorghums, are important enough to demand the attention of the farmer. They can be used readily in a rotation with grain sorghums if the latter are followed by some leguminous crop like cowpeas. The small grains bring good prices ordinarily and are in demand for home use and for shipment. They do not return much profit themselves, but in a general farm system where they make up a minor part of the total crop they may be quite valuable.

Winter wheat is the only small-grain crop that has been grown very extensively in the Texas Panhandle. In the last two years it has been a very important crop. The price per bushel has been high and the yields exceptionally good over a large part of the Panhandle country. Considerable spring oats has been grown also.

In the following paragraphs each crop is discussed as to its adaptability, importance, yield, quality, varieties, and rates and dates of seeding. Its rank in the list of crops that can be profitably grown in the Panhandle of Texas is also given.

WHEAT.

Wheat is by far the most important of the small-grain crops grown in the Panhandle. In 1909 the State of Texas was credited with 320,000 acres of wheat and a total production of 2,561,000 bushels. For 1915 the area in wheat was estimated as 1,475,000 acres and the total production as 22,862,000 bushels. This is an increase of 360 per cent in area and 800 per cent in yield.

The newly developing Panhandle country has increased its wheat area more rapidly than the older parts of the State. The Panhandle wheat area in 1909 was 88,170 acres. The yields were very low that year. A very careful estimate places the Panhandle area in wheat in 1915 at 550,000 acres, with an average acre yield of 20 bushels. This makes 11,000,000 bushels, or about half the wheat grown in the State. This increased Panhandle acreage in 1915 was due to two causes, (1) to the good yields and high prices obtained in 1914 and (2) to the development of new communities in the Panhandle. This wheat acreage is distributed to some extent over the whole Panhandle, but by far the larger part is in the east-central and northeastern section.

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[1] Full directions for the treatment of all grain smuts are given in Farmers' Bulletin 507, entitled "The smuts of wheat, oats, barley, and corn," which may be obtained free on application to the United States Department of Agriculture.

Judged by the large yields in 1915, wheat might be considered a rival of the grain sorghums. When the average yields of the two crops are considered for a number of years this apparent rivalry disappears.

WINTER WHEAT.

The wheat grown in the Panhandle of Texas is almost entirely winter wheat. Winter varieties are much better adapted to this section than the spring wheats.

The winter wheats that are best adapted are the hard red, or Crimean, group, of which the Turkey, Crimean, and Kharkof are well-known varieties. The Turkey is the leading variety in the tests at the Amarillo Cereal Field Station, with an average yield for 10 years of 13.2 bushels per acre. The Beloglina wheat comes next, with an average yield of 12.2 bushels per acre. The Crimean and Kharkof wheats are varieties very similar to the Turkey. A view of the experimental plats at this station is shown in figure 5.

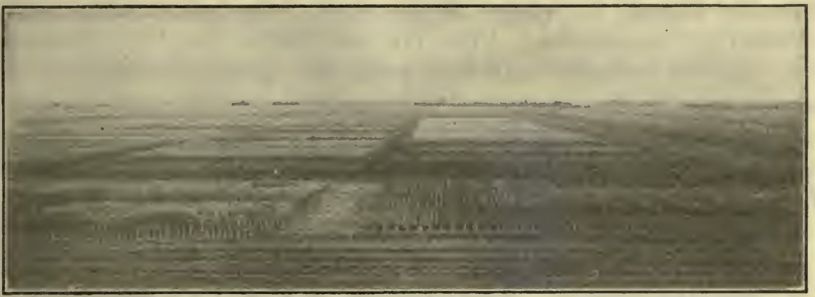

FIG. 5.—View looking south over the Amarillo Cereal Field Station in June, 1912, showing the cereal nursery in the foreground and field plats in the rear. Note the level surface of the Plains.

Farther east the soft or semihard red winter wheats are grown. Well-known varieties are the Mediterranean and Sibley Golden. At Amarillo the Diehl Mediterranean, a semihard red wheat, ties the Crimean for third place in yield. It has the advantage of having longer straw than the hard red varieties but the disadvantage of shattering more if not harvested as soon as ripe.

Wheat should be sown about October 15, though any time from October 1 to November 1 will give good results in the average season. The amount of moisture in the soil at seeding time and the weather conditions during the winter and spring have as great, if not a greater, influence upon the subsequent yield as the date on which the crop is sown.

Three pecks per acre is the rate recommended, and even lighter seedings have given excellent results. The rate of seeding will depend upon the quality of the seed, the amount of moisture in the soil, and the time of year the seeding is done. Good seed can be sown at a lighter rate than poor seed. Less seed is necessary on land that has plenty of moisture than where the soil is rather dry. Much of the seed may not germinate in soil that is lacking in moisture. Where the seeding is done early, less seed can be used than where seeding is late.

In a word, use good seed of the Turkey type and sow at the rate of 3 pecks per acre about October 15 on well-prepared land.

SPRING WHEAT.

Spring wheats, both the durum and common varieties, have proved much inferior in yield to the winter wheats. Practically no spring wheat is grown by the farmers in the Panhandle. It is not necessary, therefore, to devote much space to discussing this crop. Among common wheats the Fretes is the best variety, according to the results of a 10-year test. The Humera, which has been grown in field plats at Amarillo only four years, has given promise of being better than the Fretes.

The better yielding durum wheats are the Saragolla, Marouani, and Kubanka, in the order named. Neither the common spring nor the durum wheats can be recommended for growing in the Panhandle.

EMMER AND SPELT.

Emmer and spelt are closely related to wheat, but are grown for feed and not for making flour. They are similar in feeding value to oats and are used for much the same purposes. The kernels remain inclosed in the glumes, or hulls, after thrashing, as do most oats. The straw is of little value as feed. These grains are not as hardy as winter wheat. They should be seeded at the rate of 5 pecks per acre. The best time to sow is early in October.

There are both winter and spring varieties of emmer. Both have been grown in the Panhandle. The spring variety generally has very short straw and is not as good a yielder as the winter variety. Only the winter variety of spelt has been grown. Black Winter emmer has produced an average yield of 16.9 bushels for the 10 years, 1906 to 1915, inclusive.

Red Winter spelt has an average yield of 20.1 bushels per acre for the 10-year period just mentioned. This is a greater yield than was produced by the emmer. The emmer, however, makes up in feed value by having a thinner and softer hull than the spelt. This makes the emmer a slightly more desirable feed. Neither of these crops yields as well as the better varieties of oats. For this reason they are not recommended as good crops for this section.

RYE.

Only winter varieties of rye have been grown with any degree of success. Spring rye has not given even a promise of making good. Winter rye is more winter hardy than winter wheat, but does not equal that grain in yield. It nearly always comes through the winter in good shape and makes a vigorous growth in the spring. If sown early it makes good pasturage both in the fall and in the spring. It is no better than wheat, perhaps, for pasturage, but on account of its winter hardiness it should be used more commonly than it now is by the farmer.

Two varieties of winter rye, one called the Kansas, originally obtained from that State, and the Ivanof, imported from Russia, have been grown for 10 years at the Amarillo Cereal Field Station and for shorter periods at Channing, Chillicothe, and Dalhart. For the 10 years, 1906 to 1915, the average yields per acre at Amarillo were 11.3 bushels for the Kansas and 10.1 for the Ivanof. In appearance and manner of growth these two varieties are quite similar. The straw is always of good length to bind securely.

Winter rye has made very low grain yields some years, but has never failed to produce more seed than was sown. This can not be said of the wheats. When rye is to be used for pasturage it should be sown early in September at about 4 pecks per acre, and when grown for grain it should be seeded about the middle of October at 3 pecks per acre. Very little rye is now grown in the Panhandle.

OATS.

The total value of the oat crop of Texas in 1915 is given as $18,638,000, compared with $24,462,000 for wheat. The same ratio does not hold for the Panhandle district, however, where oats is entirely a spring crop. Here the area devoted to oats is only about half that used for growing wheat. Next to winter wheat, spring oats is the best small-grain crop. At the Amarillo Cereal Field Station for the 10 years from 1906 to 1915 the average yield of the best variety was 21.9 bushels per acre. This is not a large yield and would return only a small profit.

While the yields are not large, the oat crop in the Panhandle has never failed entirely to make grain. It has made better yields than either emmer or spelt and is considered a better crop by the farmers. It has given uniformly better results than other spring small grains.

The Rustproof group of oats, of which the Red Algerian and Red Rustproof, or Texas Red, are good examples, has given the highest yields. The varieties of this group have large reddish brown kernels. These are really winter oats, but are grown from spring seeding in the Panhandle.

The Burt group has smaller kernels, which are quite variable in color, ranging from yellowish brown to dark brown or almost black. They are often quite distinctly striped. A typical variety of this group is the Burt, C. I. No. 293. It matures a little earlier than the Rustproof group and has produced slightly lower yields.

The Sixty-Day group, which includes the Sixty-Day and Kherson, ranks third in yield. The varieties of this group have small yellow kernels. They ripen between the Burt and the Rustproof.

Oats should be sown early in the spring in the Panhandle. March 1 is the best average date. The rate that has given the best results is 5 pecks per acre.

All varieties of oats shatter more or less and should be harvested as soon as ripe.

BARLEY.

Barley has not been a successful crop in the Texas Panhandle. Spring barley has made very poor yields, averaging less than 10 bushels per acre. Winter barley has made much better yields than spring barley, but only one variety, the Tennessee Winter, has given any promise of making a crop worth while. The average yield per acre of this variety in the 10 years, 1906 to 1915, inclusive, is 14.4 bushels of 48 pounds. In the number of pounds produced per acre it is somewhat lower than the best oat variety for the same period. It failed entirely, due to winterkilling, in two years, 1907 and 1909. Winter barley should be sown about the middle of October at the rate of 5 pecks per acre. Barley is not recommended as a crop for the Panhandle of Texas.

PROSO.

Proso (*Panicum miliaceum*) is a species of millet introduced into this country from Russia. It is often called "hog millet" and "broomcorn millet" in the United States. It is grown for grain and not for hay. The grain is of value for feeding to stock, particularly to hogs, sheep, and poultry. Young chicks are especially fond of it. The chief value of this crop to the dry-land farmer is its earliness. Proso can produce a crop of seed in two months or less from the time of seeding and so may be used as a catch crop.

There are several varieties of proso, the differences being mainly in the color of the seed and the length of the straw. Some varieties have short and some have long straw, but the leaves are few in all. A black-seeded sort, the Black Voronezh, has produced the best average yield (11.8 bushels) per acre in the nine years, 1907 to 1915, inclusive. This is the variety recommended for use in the Panhandle. Sowing may be done in the latter part of May or in June, using 20 pounds of seed per acre. The seed can be sown with an ordinary drill. Proso is harvested with a grain binder and thrashed the same as the other small grains.

This crop should be tried for home use, but it is not likely to be profitable if grown for market.

RELATIVE RANK OF THE SMALL-GRAIN CROPS.

The small-grain crops in the Panhandle of Texas rank in the following order, on the basis of average yields:

1. Winter wheat.
2. Spring oats.
3. Winter barley.
4. Winter rye.
5. Proso.
6. Durum spring wheat.
7. Common spring wheat.
8. Winter spelt.
9. Winter emmer.

Those recommended to be grown rank as follows:

1. Winter wheat.
2. Spring oats.
3. Winter rye.
4. Proso.

GRAIN SORGHUMS AND CORN.

The grain sorghums, especially the milo, kafir, and feterita varieties, are the most important grain crops for the Panhandle of Texas. About three-fourths of the total cultivated area is devoted to these crops. They can be profitably grown in practically the whole section. They are not discussed in detail in this paper, however, as several bulletins on them are already available. See the list given at the end of this bulletin.

Corn is grown in the Panhandle in a limited way. The acreage devoted to its production is small and somewhat scattered. Most of it is grown in the east-central part just below the cap rock and along the Canadian River. It can not successfully compete with the grain sorghums either in total tonnage or in yield of grain per acre. The quality of the crop produced usually is poor, owing to earworm injury. Bulletins discussing this crop on the Great Plains are available.

CROP VARIETIES RECOMMENDED.

The varieties of small grains that are recommended for the Panhandle may be summed up as follows:

(1) *Winter wheats.*—The hard red varieties belonging to the Crimean group, such as the Turkey, Kharkof, Crimean, and Beloglina.

(2) *Spring oats.*—The large red oats of the Rustproof group, represented by Red Algerian and Red Rustproof. These are really winter oats but are here grown from spring seeding.

(3) *Winter rye.*—Any good winter variety.

(4) *Proso.*—The earlier maturing varieties, of which Black Voronezh is the best.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE TREATING OF CEREAL PRODUCTION IN THE SOUTHERN GREAT PLAINS.

AVAILABLE FOR FREE DISTRIBUTION.

Sixty-Day and Kherson Oats. (Farmers' Bulletin 395.)
Corn Cultivation. (Farmers' Bulletin 414.)
Seed Corn. (Farmers' Bulletin 415.)
Oats: Growing the Crop. (Farmers' Bulletin 424.)
Barley: Growing the Crop. (Farmers' Bulletin 443.)
The Smuts of Wheat, Oats, Barley, and Corn. (Farmers' Bulletin 507.)
Durum Wheat. (Farmers' Bulletin 534.)
Milo as a Dry-Land Grain Crop. (Farmers' Bulletin 322.)
Better Grain-Sorghum Crops. (Farmers' Bulletin 448.)
Kafir as a Grain Crop. (Farmers' Bulletin 552.)
Use of Corn, Kafir, and Cowpeas in the Home. (Farmers' Bulletin 559.)
Uses of Sorghum Grain. (Farmers' Bulletin 686.)
The Feeding of Grain Sorghums to Live Stock. (Farmers' Bulletin 724.)
Tests of Corn Varieties on the Great Plains. (Department Bulletin 307.)
The Grain Sorghums: Immigrant Crops That Have Made Good. Separate 625, Yearbook, 1913.

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

Feterita, a New Variety of Sorghum. Bureau of Plant Industry Circular 122-C. Paper, 5 cents.
Three Much-Misrepresented Sorghums. Bureau of Plant Industry Circular 50. Paper, 5 cents.
The Importance and Improvement of the Grain Sorghums. Bureau of Plant Industry Bulletin 203. Paper, 10 cents.
Grain-Sorghum Production in the San Antonio Region of Texas. Bureau of Plant Industry Bulletin 237. Paper, 5 cents.
The Kaoliangs: A New Group of Grain Sorghums. Bureau of Plant Industry Bulletin 253. Paper, 15 cents.
Cereal Experiments in the Texas Panhandle. Bureau of Plant Industry Bulletin 283. Paper, 10 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 739 JUNE 1, 1916.

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

CUTWORMS AND THEIR CONTROL IN CORN AND OTHER CEREAL CROPS.

By W. R. WALTON and J. J. DAVIS,

Entomological Assistants, Cereal and Forage Insect Investigations.

IMPORTANCE AND NATURE OF CUTWORM INJURY.

Numerous complaints of the ravages of cutworms, especially in relation to corn, are received each season by the department. Prompt action is necessary for controlling cutworms after their presence becomes noticeable in the spring, which is usually about the time the corn begins to sprout. Because of the fact that the delay necessary between the time the worms make their appearance and the time a reply can be received from the department is often disastrous to the crop, the importance of recognizing these insects and knowing how to control them is evident.

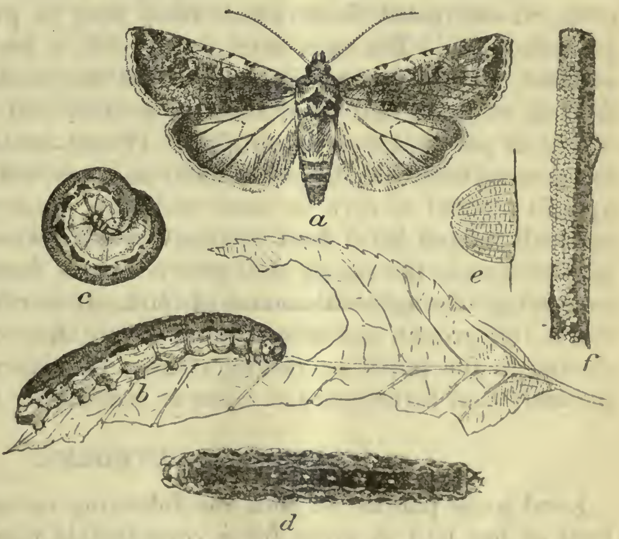

FIG. 1.—Variegated cutworm (*Peridroma margaritosa*): *a*, Moth; *b*, normal form of caterpillar, side view; *c*, same in curved position; *d*, dark form, view of back; *e*, greatly enlarged egg, seen from side; *f*, egg mass on twig. (From Howard.)

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Cutworm injury almost invariably occurs in the spring, the plants usually being cut off at the surface, or a little below the surface, of the ground, beginning as soon as the first plants sprout and continuing until late June or early July, by which time the worms are full grown. Feeding takes place at night, the worms resting during the day beneath débris or in the soil at a depth of from one-half to 1 inch below the surface, and since they closely resemble the color of the soil in most cases, the cause of the injury is often not apparent. However, if the soil surrounding the cut-off plant be examined carefully, the culprit will quite likely be found curled up in the soil as illustrated (fig. 1, *c*).

LIFE HISTORY OF CUTWORMS.

The various cutworms are known under a number of popular names, such as the glassy cutworm, greasy cutworm, variegated cutworm, clay-backed cutworm, etc., but the injuries caused by them are very similar and their habits in general are also much the same. The parents of cutworms are grayish or brownish moths or "millers," which commonly occur at lights during summer evenings. Each moth may lay from 200 to 500 eggs, either in masses or singly, in fields covered with dense vegetation, and hence are to be found more often in cultivated fields which have been in grass or weeds the preceding fall. The eggs hatch in the fall, a few weeks after they are laid, usually during September, and the young cutworms, after feeding on grass and other vegetation until cold weather, pass the winter as partly grown caterpillars. If such infested fields are left to grass, no noticeable injury is likely to occur, but when it is broken up and planted to corn or other wide-row crops, the worms, being suddenly placed on "short rations," wreak havoc with the newly planted crops, the nearly full-grown worms feeding greedily and consuming an enormous amount of food. In northern latitudes they attain full growth and stop feeding in late June or early July, and change to the pupal or resting stage. The injury often ceases so suddenly that farmers are at a loss to account for the fact.

CONTROL OF CUTWORMS.

Land to be planted to corn the following spring, especially such land as has laid in grass for a considerable time and is likely to contain cutworms, should be plowed in midsummer or early fall about the time the eggs are laid, or better, before the eggs are laid, for then vegetation which is suitable for the moths to lay their eggs upon is removed. The earlier the preceding year grasslands to be planted to corn are plowed, the less will be the probability that the cutworm moths will have laid their eggs thereon, and the less, consequently, will be the danger of injury by cutworms the following year.

Late fall and winter plowing of grasslands, although not as effective as early plowing, will destroy many of the hibernating cutworms, as well as such other important corn pests as white grubs, and should be practiced when earlier plowing is impracticable.

Pasturing hogs upon land supposed to harbor cutworms is a beneficial practice, as these animals root up and devour insects of many kinds, including cutworms, in large numbers. Farm poultry, if trained to follow the plow, will prove of inestimable value.

When cutworms are found to be abundant on corn land, the use of the poisoned bait is recommended. This may be prepared as follows: Mix 50 pounds of wheat bran, 2 pounds of Paris green, and 6 finely chopped oranges or lemons. Then bring the whole mixture to the consistency of a stiff dough by the addition of a low-grade molasses, such as is used in cattle rations, adding water when necessary. Distribute this bait over the infected field in small lumps, taking care to sprinkle it sparingly around each hill. In case bran can not be readily obtained, middlings or alfalfa meal may be successfully substituted. In fields known to be infested, the distribution of this bait should be started as soon as the corn begins to appear above ground so that the cutworms may be eliminated as quickly as possible and the injured hills promptly replanted. During the warmer spring months cutworms do most of their feeding at night and burrow into the soil to the depth of an inch or two during the day, so that the bait will usually be more effective if applied during the late afternoon or early evening hours.

Frequently cutworms migrate to cultivated fields from adjoining grassland, and in such cases the crops can be protected by running a narrow band of the poisoned bait around the edge of the field or along the side nearest the source of infestation.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS.

AVAILABLE FOR FREE DISTRIBUTION.

Cotton Bollworm. (Farmers' Bulletin 290.)
Common White Grubs. (Farmers' Bulletin 543.)
The Chalcis-fly in Alfalfa Seed. (Farmers' Bulletin 636.)
The Grasshopper Problem and Alfalfa Culture. (Farmers' Bulletin 637.)
The Hessian Fly. (Farmers' Bulletin 640.)
Alfalfa Attacked by the Clover-root Curculio. (Farmers' Bulletin 649.)
The Chinch Bug. (Farmers' Bulletin 657.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
The True Army Worm and its Control. (Farmers' Bulletin 731.)
The Hessian Fly Situation in 1915. (Office of Secretary Circular 51.)
The Spring Grain Aphis or "Green Bug" in the Southwest and the Possibilities of an Outbreak in 1916. (Office of the Secretary Circular 55.)
Southern Corn Rootworm, or Budworm. (Department Bulletin 5.)
Western Corn Rootworm. (Department Bulletin 8.)
The Oat Aphis. (Department Bulletin 112.)
The Alfalfa Caterpillar. (Department Bulletin 124.)
Clover Mite. (Entomology Circular 158.)
Clover-root Curculio. (Entomology Bulletin 85, pt. III.)
Maize Billbug. (Entomology Bulletin 95, pt. II.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

The Larger Corn Stalk-borer. (Farmers' Bulletin 634.) Price, 5 cents.
The Southern Corn Leaf-beetle. (Department Bulletin 221.) Price, 5 cents.
The Sharp-headed Grain Leafhopper. (Department Bulletin 254.) Price, 5 cents.
The Pea Aphis with Relation to Forage Crops. (Department Bulletin 276.) Price, 15 cents.
Joint-worm. (Entomology Circular 66.) Price, 5 cents.
Some Insects Affecting Production of Red Clover Seed. (Entomology Circular 69.) Price, 5 cents.
Wheat Strawworm. (Entomology Circular 106.) Price, 5 cents.
Western Grass-stem Sawfly. (Entomology Circular 117.) Price, 5 cents.
Clover Root-borer. (Entomology Circular 119.) Price, 5 cents.
Alfalfa Gall Midge. (Entomology Circular 147.) Price, 5 cents.
Lesser Clover-leaf Weevil. (Entomology Bulletin 85, pt. I.) Price, 5 cents.
Sorghum Midge. (Entomology Bulletin 85, pt. IV.) Price, 10 cents.
New Mexico Range Caterpillar. (Entomology Bulletin 85, pt. V.) Price, 10 cents.
Contributions to Knowledge of Corn Root-aphis. (Entomology Bulletin 85, pt. VI.) Price, 5 cents.
So-called "Curlew Bug." (Entomology Bulletin 95, pt. IV.) Price, 10 cents.
False Wireworms of Pacific Northwest. (Entomology Bulletin 95, pt. V.) Price, 5 cents.
Alfalfa Looper. (Entomology Bulletin 95, pt. VII.) Price, 5 cents.
Leafhoppers Affecting Cereals, Grasses, and Forage Crops. (Entomology Bulletin 108.) Price, 20 cents.
Spring Grain-aphis or Green Bug. (Entomology Bulletin 110.) Price, 25 cents.
Preliminary Report on Alfalfa Weevil. (Entomology Bulletin 112.) Price, 15 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 740 JULY 8, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

HOUSE ANTS: KINDS AND METHODS OF CONTROL.[1]

By C. L. Marlatt,
Entomologist and Assistant Chief.

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INTRODUCTION.

There are now in North America a considerable number of species of ants which under favoring conditions may inhabit dwelling houses or other heated buildings, constructing their nests and breeding continuously in the woodwork or masonry, or in articles of furniture or of ornament, and subsisting on food materials which they find about kitchens and pantries or scattered in living rooms. Other species nesting in gardens and lawns or under adjacent walks may occasionally enter houses as foragers or as accidental guests.

It is interesting to note that, of the ants which in North America frequent houses and construct their nests therein, practically all are of tropical origin, and most of them are Old-World species.

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[1] The authority for the scientific names and the source of many records of the less well-known house ants given in this bulletin is the notable work on American ants by Dr. W. M. Wheeler, entitled "Ants: Their Structure, Development, and Behaviour" (1910). Dr. Wheeler has also read the text of this bulletin and furnished some notes not available in print.

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It is a matter of further interest that, with the exception of the European meadow ant, practically all of the ants which have been introduced into North America, either from the Old World or from South America, are such tropical species and potential house pests. All of these introduced species have been brought to North America and many of them given cosmopolitan distribution through the agency of commerce. The tropical ants in their native countries are still normally outdoor species, although in the Tropics they also frequent human habitations, including ships, and, by colonizing in ships' cargoes, are easily given world-wide distribution. Some of these Old-World species have become established as out-of-door species in the New-World Tropics, but in temperate regions they are able to survive only in dwellings, hothouses, mills, or other structures where the requisite warmth is maintained. The ability of these imported tropical species to maintain themselves is largely due to the protection from competition with our native species afforded by this house-dwelling habit.

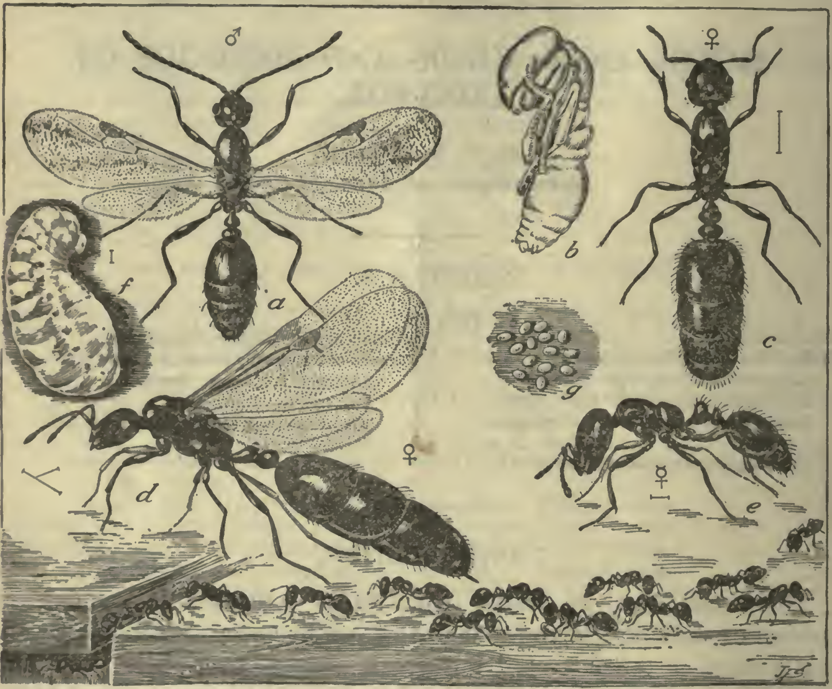

FIG. 1.—The little black ant (*Monomorium minimum*): *a*, Male; *b*, pupa; *c*, female; *d*, same with wings; *e*, worker; *f*, larva; *g*, eggs; group of workers in line of march below. All enlarged, the lettered illustrations all drawn to the same scale. (Original.)

None of these ants, with the exception, in rare instances, of the carpenter ant, are so destructive to household effects or supplies as they are annoying from the mere fact of their presence and their faculty of "getting into" articles of food, particularly sugars, sirups, cakes, candies and other sweets, and cooked foods of animal origin. Having once gained access to articles of this sort, the discovery is at once reported to the colony, and in an incredibly short time the premises may be swarming with these unwelcome visitors.

KINDS OF NORTH AMERICAN HOUSE ANTS.

The different kinds of North American house ants may be grouped on the basis of origin as follows: (1) Tropical Old-World ants, represented by 12 species; (2) ants introduced from the New-World Tropics, represented by 5 species; (3) native North American ants of temperate regions which occasionally inhabit dwelling houses, represented by 2 species; and (4) such occasional garden and lawn ants as may from time to time become accidental house pests by extending their forays into dwelling houses in quest of food, of which 4 native North American species are discussed, and also the introduced European meadow ant.

INTRODUCED TROPICAL OLD-WORLD ANTS.

The little red ant,[1] or Pharaoh's ant (fig. 2), is the best known house species. It has attained a thoroughly cosmopolitan distribution and has been domesticated so long that it is now difficult to determine its exact origin, except to place it generally in the Old-World Tropics. It was originally a soil ant, nesting out of doors in warm countries, and doubtless continues this habit in the tropics of both hemispheres. In temperate regions it passes its entire existence in heated houses.

Three other species of the same genus of Old-World tropical ants are recorded as having been brought to our shores and as having gained foothold, occasionally in dwellings.[2] None of these species have, however, so far established any important record in this country as house pests, although they may be expected to appear at any time in dwelling houses and other heated structures, particularly in the southern United States, and possibly farther north along the Atlantic seaboard. One of these, *Monomorium salomonis*, is stated to be the most abundant of North African ants, and to have been widely distributed by commerce and to occur in most tropical and subtropical countries. A native species of the same genus,[3] known as the little black ant, is referred to elsewhere.

Two Old-World agricultural or harvester ants[4] have been brought to this country by commerce and are now fairly well established in tropical America, and are potential house pests. One of these, *Pheidole megacephala*, was formerly the important house ant of Madeira, occurring in prodigious numbers throughout the southern portion of the island and up to an elevation of 1,000 feet, nesting out of doors under nearly every stone, and in houses generally. It is stated also that this ant is very common in the Bermudas and West Indies and will probably be found in Florida, and that wherever it gains foothold in subtropical countries it is able to propagate very rapidly and to exterminate the indigenous ant fauna; in fact, several instances of this kind have been noted. This ant, on the other hand, has itself lately been driven out and practically exterminated in Madeira by the Argentine ant,[1] which latter ant has also, in New Orleans and elsewhere in the United States, similarly displaced our native ants. As North American house ants, however, neither of these Old-World harvester ants has so far assumed any importance, although both probably occur in Florida.

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[1] *Monomorium pharaonis* L.

[2] *Monomorium salomonis* L., *Monomorium destructa* Jerdon, and *Monomorium floricola* Jerdon.

[3] *Monomorium minimum* Buckley.

[4] *Solenopsis geminata* Fab. subspecies *rufa* Jerdon and *Pheidole megacephala* Fab.

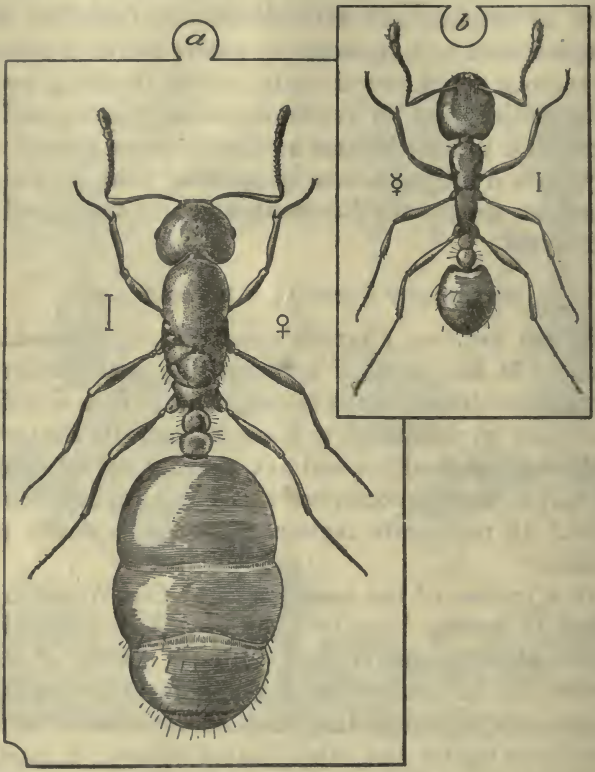

FIG. 2.—The little red or Pharaoh's ant (*Monomorium pharaonis*); *a*, Queen or female; *b*, worker. Both drawings enlarged to the same scale. (Original.)

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[1] *Iridomyrmex humilis* Mayr.

Six other Old-World tropical ants have been recorded as introduced house-infesting species in North America.[1] These, like other Old-World ants, have been brought in through the agency of commerce and have gained foothold in tropical America and are occasionally found nesting in hothouses and other heated structures in temperate regions.

One of these ants, *Prenolepis longicornis*, a slender, black species with unusually long legs and antennæ or "feelers," has earned the common name of "crazy ant" from its habit of running about, usually singly and apparently aimlessly, with a quick, jerky motion. This ant has long been a common species in the greenhouses of temperate Europe and America, and in some of these, as in the Jardin des Plantes in Paris, it has been a permanent resident for more than 40 years. It has acquired a footing in tropical Florida, and probably also in other localities in the Gulf States, and has been reported as infesting, even to the top floors, large apartment buildings in New York City, and also as occurring in hotels and flats in Boston. It is a common house ant in the District of Columbia. India is believed to be the original home of this ant, whence it has been carried to all tropical countries in ships, and it has been accompanied in its wanderings by three insect messmates, namely, two beetles and a small cricket.

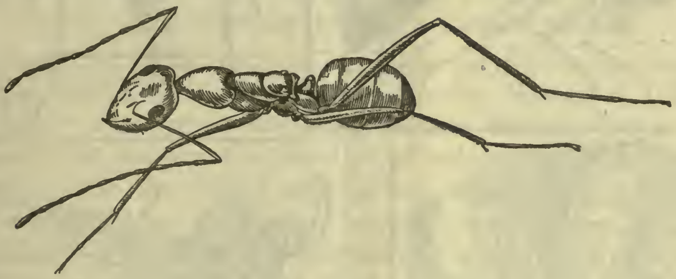

FIG. 3.—An introduced tropical Old-World ant, *Plagiolepis longipes*. Enlarged. (After Wheeler.)

A related species, *Prenolepis vividula*, is a common greenhouse pest in Europe and is reported as having been found in greenhouses in this country; in one instance as far north as Canada. Another of these Old-World ants, *Plagiolepis longipes* (fig. 3), will probably ultimately come into prominence as a house species on this continent. Its original home is given as Cochin China, but it has already established a foothold in widely separated parts of the world. On the island of Reunion, for example, it is very abundant and is reported to be driving out some of the primitive species. It has also been recorded on this continent from Todos Santos, Lower California.

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[1] *Tetramorium guineense* Fab., *Tetramorium simillimum* Roger, *Tapinoma melanocephalum* Fab., *Prenolepis longicornis* Latr., *P. vividula* Nyl., and *Plagiolepis longipes* Jerdon.

INTRODUCED TROPICAL NEW-WORLD ANTS.

Of the ants introduced into North America from the New-World Tropics the one of greatest economic importance is what has now come to be generally known as the Argentine ant (fig. 4)[1] from its supposed Argentine origin. It is known, however, to be a serious pest in Brazil and Uruguay, as well as in Argentina. It is sometimes also called the New Orleans ant, from the fact that it gained its first foothold from colonies brought in, presumably from Brazil, by some ships' cargoes to the port of New Orleans. It is a much worse house pest than even the little red ant or any of the other house ants and is in addition a very serious enemy of field and garden crops and orchard trees. It has rapidly spread from the point of introduction throughout Louisiana and has been carried by traffic to California, where it has become a serious pest in citrus orchards in the southern part of the State, and in houses as far north as San Francisco. It is undoubtedly destined to extend its outdoor range

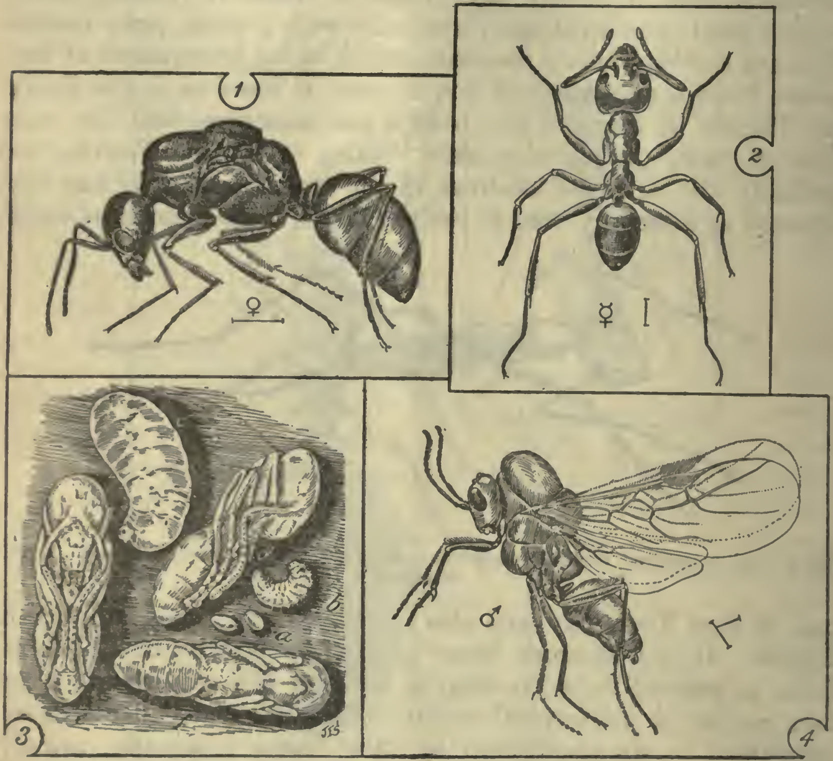

FIG. 4.—The Argentine ant (*Iridomyrmex humilis*). *1*, Wingless female. *2*, Worker. *3*, Immature stages: *a*, Eggs; *b*, young larva; *c*, full-grown larva; *d*, pupa, side view; *e*, pupa, ventral view; *f*, pupa, dorsal view. *4*, Male. All enlarged to the same scale. (Original.)

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[1] *Iridomyrmex humilis* Mayr.

wherever climatic conditions permit and as a house and greenhouse pest over a much wider area. Its rôle as an exterminator of native ants in the New Orleans district and in the island of Madeira has already been referred to. It is the only one of the imported tropical ants which causes any large monetary losses. The other species, as elsewhere noted, are for the most part merely annoying.

Four other species of ants from tropical America have gained, through the agency of commerce, some foothold as house pests in the southern and eastern United States, and manage to live for considerable periods of time in northern heated houses.[1]

One of these, *Prenolepis fulva* subspecies *pubens*, has been recorded from the District of Columbia, where it was found infesting one of the hothouses of the Department of Agriculture. It is believed to be a native of Brazil, but now occurs quite abundantly in Cuba and other West Indian Islands. It is still a comparatively rare house pest, however, in temperate regions of North America, and, except in the Tropics, undoubtedly can not survive outside of heated buildings.

NATIVE NORTH AMERICAN ANTS OF TEMPERATE REGIONS.

Only one North American ant of temperate regions has become a true house dweller and pest. This distinction belongs to the little "thief ant,"[2] a native of our Northern and Eastern States. The workers of this ant are very small, and yellowish in color. They frequently, as do also Old-World species of the genus, inhabit the gallery walls of other and larger ants, where they are apparently unnoticed, and kill and eat the helpless larvæ and pupæ of their apparently unconscious hosts. The thief ant may, however, lead an independent existence, and has been reported as a frequent pest in dwellings. It feeds on any animal matter, including dead insects, and has been recorded as attacking the sprouting kernels of Indian corn. This species can be readily distinguished from the little red, or Pharaoh's, ant by its much lighter color and smaller size.[3] This species is reported by C. H. Popenoe, of the Bureau of Entomology, United States Department of Agriculture, as nesting in houses very much as does the little red ant, colonies of the thief ant having been found, for example, in an envelope, and again in a box of photographic dry plates.

The carpenter ant[4] (fig. 5) should be considered in the list of house ants, although perhaps only accidentally, and under exceptional circumstances, a house-infesting species. The carpenter ant of North America, a subspecies or variety of the European and Asiatic species of the same name, is dark brown or black in color, and is the largest of the house-frequenting ants, the workers varying from one-fourth to one-half inch in length and the winged female attaining a length of nearly an inch. It normally constructs its galleries in logs and dead trees in forests, but not infrequently, in the case of wooden houses, and especially those in or near forested tracts, gains access through porch beams or the underpinning of such houses and mines and weakens the supporting timbers and other woodwork. As a rule it affects only the decaying portions of the wood, but sometimes carries its channels into the sound wood. Many instances of damage of this sort have been reported, possibly some of them, however, due to confusion of the work of this ant with that of the common termite or so-called white ant.[1]

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[1] *Prenolepis fulva* Mayr subspecies *pubens* Forel, *Neoponera villosa* F. Smith, *Camponotus abdominalis* Roger subspecies *floridanus* Buckley, and *Pheidole flavens* Roger subspecies *floridanus* Emery.

[2] *Solenopsis molesta* Say.

[3] It is further distinguished by the possession of very rudimentary eyes, and a two-jointed instead of three-jointed "club" to the antennæ.

[4] *Componotus herculeanus* L., subspecies *pennsylvanicus* De G.

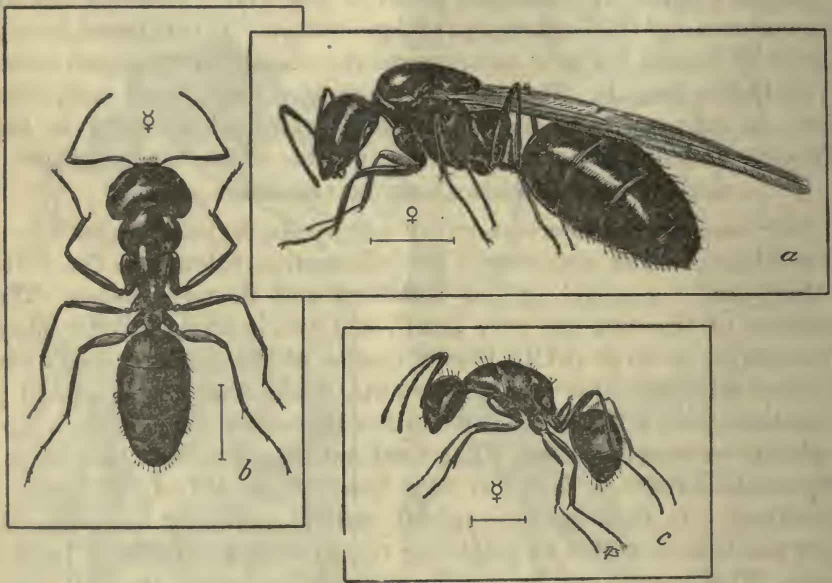

Fig. 5.—The carpenter ant (*Camponotus herculeanus pennsylvanicus*) : *a*, Winged female ; *b*, worker major ; *c*, worker minor. All enlarged to same scale. (Original.)

GARDEN AND LAWN ANTS AS HOUSE PESTS.

Almost any of the common garden or lawn ants which build their little crater nests in lawns or in soil about houses may become temporarily or on occasion house pests in their search for food substances. Four native ants and one introduced species have achieved notoriety in this way.[2] One of these, referred to in earlier circulars issued by this department on house ants as the little black ant[3]

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[1] *Leucotermes flavipes* Kollar.

[2] *Monomorium minimum* Buckley, *Lasius niger* L. var. *americanus* Emery, *Prenolepis imparis* Say, and *Formica fusca* L. var. *subsericea* Say.

[3] *Monomorium minimum* Buckley.

(fig. 1), is essentially a lawn or meadow ant, and its entrance into houses is due to chance or accident. Its small nests, with the opening surrounded by its protecting wall of fine grains of soil, can be frequently noted in lawns, and if these nests are opened the colonies will be found to consist of workers, with one or more much larger gravid females. When these or other lawn ants gain access to houses, attracted by food supplies, the nuisance can often be eliminated by tracing them back to their outdoor colony and destroying the latter, as hereinafter described.

Perhaps the most abundant and widespread lawn or garden ant is a small yellowish-brown species which may be given the common name of the American lawn ant.[1] Its crater nests are exceptionally abundant throughout the Northern States, and not infrequently a dozen or more nests may occur on a square yard of lawn surface. In addition to the fact that it occasionally gains entrance to houses and becomes annoying as a depredator on larder supplies, it is a lawn and garden pest of some importance; and, furthermore, has the reputation of hoarding over winter the eggs of aphids and colonizing the young aphids in the spring on their host plants, thus becoming a very important factor in increasing the damage to garden and field crops by these injurious insects. In the case of lawns and meadows, aside from the harboring of injurious aphids, direct injury from this ant is probably negligible, or is offset by the actual benefit which may result from the bringing up of its little craters of sand and earth to form a sort of top dressing or soil mulch. The other two native garden and lawn ants have similar habits.

In this same class of outdoor ants which may occasionally find entrance into houses should be included the common European meadow ant,[2] one of the few Old-World ants of temperate regions which has been brought to America. This ant has readily accommodated itself to conditions of urban existence in the eastern United States, and its colonies occur in lawns and often under pavements, or beneath flagging or stones in yards. These colonies are often large and may frequently be uncovered in masses of a quart or more, on turning over stones in yards or lifting flagging in paths.

HABITS AND LIFE HISTORY OF HOUSE ANTS.

In habits and life history these ants are all much alike and, in common with other social insects, present that most complex and interesting phase of communal life, with its accompanying division of labor and diversity of forms of individuals, all working together in the most perfect harmony and accord. The ants ordinarily seen in houses are neuters or workers. In the colony itself, if it be discovered and opened, will be found also the larger wingless females and, at the proper season, the winged males and females. During most of the year, however, the colony consists almost exclusively of workers, with one or more perfect wingless females. Winged males and females are produced during the summer and almost immediately take their nuptial flight. The males soon perish, and the females shortly afterward tear off their own wings, which are but feebly attached, and set about the establishment of new colonies. The eggs, which are produced in extraordinary numbers by the females or "queen" ants, are very minute, oval, whitish objects, and are cared for by the workers, the young larvæ being fed in very much the same way as in the colonies of the hive bee. The so-called ant eggs, in the popular conception, are not eggs at all, but the white larvæ and pupæ, and those of females or males are much larger than those of the workers and many times larger than the true eggs.

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[1] *Lasius niger* L. var. *americanus* Emery.

[2] *Tetramorium caespitum* L.

MEANS OF CONTROLLING HOUSE AND LAWN ANTS.

DESTRUCTION OF HOUSE COLONIES.

The distinctively house-inhabiting ants, such as the little red or Pharaoh's ant, and other imported species nesting in the woodwork, masonry, or articles of furniture, etc., are often very difficult to eradicate because of their inaccessibility. If the nest can be located by following the workers back to their point of disappearance, the inmates of the nest, if near by, may sometimes be reached by injecting a little bisulphid of carbon, kerosene, or gasoline into the opening by means of an oil can or small syringe. *In the use of these substances, naturally, precautions should be taken to see that no fire is present, as all of them are inflammable.* If the nest is under flooring it may sometimes be gotten at by removing a section; but, as a rule, unless the colony can thus be reached and destroyed other measures are of only temporary avail if food or other conditions continue to attract the ants and facilitate their continued breeding in the house.

The removal, therefore, of the attracting substances in houses, wherever practical, should be the first step. Ants are attracted by food material, especially cake, bread, sugar, meat, and like substances, in pantries and elsewhere, and the nuisance of their presence can be largely limited by promptly cleaning up all food scattered by children and by keeping in the pantry or storeroom all food supplies which may attract ants, in ant-proof metal containers or in ice boxes, and limiting the amount of such articles as far as possible to daily needs.

That it is possible to drive ants away from household supplies by the use of repellents, particularly camphor and naphthalene flakes or powdered moth balls, has been asserted. The use of most of such repellent substances, however, in connection with food supplies, is impracticable, and careful tests have indicated that such substances have only slightly repellent properties and bring comparatively little benefit.

The collection of ants by the use of attractive baits is frequently recommended. Perhaps as convenient a bait as any consists of small sponges moistened with sweetened water and placed in situations where they can be easily reached by the ants. These sponges may be collected several times daily and the ants swarming on them destroyed by immersion in hot water. It is reported also that a sirup made by dissolving borax and sugar in boiling water and distributed on sponges will effect the destruction of the ants in numbers. Remedies of this kind, however, are of doubtful value. They may be useful at the outset when the colonies are few and small and when most of the individuals may, by these means, be secured and destroyed. Very frequently, however, the distribution of such baits will simply result in a more wide exploitation of a good forage ground and an actual increase of the ant nuisance.

A more efficient remedy, where it can be safely used, is a sirup poisoned with arsenate of soda, the idea being that the ants will collect this poison sirup and convey it to their nests, so that not only the ants which collect the sirup are ultimately killed, but the inmates of nests feeding on it also succumb. The formula for the preparation of this sirup is as follows: One pound of sugar dissolved in a quart of water, to which should be added 125 grains of arsenate of soda. The mixture should be boiled and strained, and on cooling is used with sponges, as already described. The addition of a small amount of honey is said to add to the attractiveness to ants of this mixture. *Naturally the greatest precautions should be taken in preparing this sirup and in safeguarding it afterwards to prevent its being the cause of poisoning to human beings or domestic animals.* This method of control has been tested for three years by an expert[1] of the Bureau of Entomology of this department and has given very satisfactory results. Similar success with it has been reported by others, including persons engaged professionally in insect extermination. A related formula experimentally worked out for the Argentine ant will appear in a special bulletin on this insect.[2] This formula is as follows:

Granulated sugar	15 pounds.
Water	7½ pints.
Tartaric acid (crystallized)	¼ ounce.

Boil these ingredients together slowly for 30 minutes and allow them to cool. Then slowly dissolve three-fourths ounce sodium arsenite ($NaAsO_2$) in one-half pint of hot water. Allow this to cool, then add it to the sirup, stirring thoroughly. Add 1½ pounds of pure honey to the sirup and the mixture is ready for use.

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[1] C. H. Popenoe.

[2] Barber, E. R. The Argentine ant: Distribution and control. U. S. Dept. Agr. Bul. 377.

DESTRUCTION OF LAWN ANTS.

In the case of lawn ants where only a small area with few nests are concerned, drenching the nests with boiling water or injecting a small quantity of kerosene or coal oil will be effective, and similar treatment will apply to nests between or beneath paving stones.

Another simple means of destroying such ants in lawns of small extent is to spray the lawns with kerosene emulsion (see Farmers' Bulletin 127) or with a very strong soap wash, prepared by dissolving any common laundry soap in water at the rate of from half a pound to a pound of soap to the gallon of water.

An effective control method for larger ant colonies is to inject into the nest a quantity of bisulphide of carbon, a chemical which can be purchased at any drug store. This substance can be placed in the nest with an oil can or small syringe, the quantity varying from half an ounce for a very tiny nest to 2 or 3 ounces or more, depending on the size of the nest. An oil can or syringe with a long spout is convenient for this purpose, as this can be inserted into the nests and the liquid injected without its being too near the operator's nose. To facilitate entrance of the chemical, the ant hole can be enlarged with a sharp stick or iron rod. The depth of the injection will depend on the size of the nest—from an inch or two to greater depths. After injection of the bisulphide of carbon the entrance opening should be closed by pressure of the foot to retain the bisulphide, which will then penetrate slowly throughout the underground channels of the nest and kill the inmates. The efficiency of this remedy is increased by covering the nest immediately after the injection with a wet blanket or other heavy cloth, to better retain the fumes of the chemical. Bisulphide of carbon has a very disagreeable odor, but its fumes are not poisonous to higher animals. *As already noted, it should be kept away from fire, as its fumes are inflammable and may explode if ignited, much like gasoline vapor.*

PROTECTION FROM THE CARPENTER ANT.

The method of protection from damage by the carpenter ant is practically the same as that employed to protect from termites,[1] namely, preventing the ants from gaining access to foundation timbers by using in the foundations only timbers which have been previously impregnated with creosote. Ants infesting house timbers which have not been so protected may sometimes be reached and killed by the abundant use of kerosene injected by means of a syringe or, where the timbers are accessible, by spraying or soaking them with kerosene. All timbers which have been mined and weakened should, however, be replaced with timbers protected with creosote.

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[1] A special publication on white ants (Department Bulletin No. 333, prepared in the Bureau of Entomology) has been issued by the Department of Agriculture and may be had on application.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 741 JULY 17, 1916

Contribution from the Bureau of Entomology, L. O. Howard, Chief.

THE ALFALFA WEEVIL AND METHODS OF CONTROLLING IT.[1]

By GEO. I. REEVES and PHILIP B. MILES, *Entomological Assistants*, and THOMAS R. CHAMBERLIN, STERLING J. SNOW, and LUTHER J. BOWER, *Scientific Assistants, Cereal and Forage Insect Investigations.*

INTRODUCTION.

The alfalfa weevil destroys a great deal of alfalfa in northern Utah and southern Idaho. It also inhabits southwestern Wyoming and is spreading slowly to new territory in all directions. It may in time infest most of the United States. The adult (fig. 1), a small brown snout-beetle, and the larva (fig. 2), a green, wormlike creature, usually escape notice during the first two or three years that they are present in a locality, but as soon as they become numerous enough to do harm they are readily found, and their effect upon the appearance of the fields is conspicuous. Vigorous treatment is then necessary to prevent partial or total destruction of the first and second crops. The purpose of this bulletin is to show how serious the attack is to the farmer, how much territory it embraces and how it spreads, and to describe the insect, its work, and the methods which are effective in dealing with it.

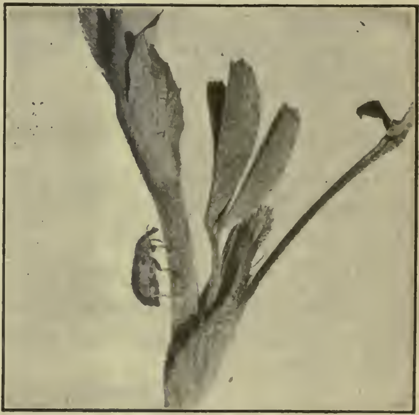

FIG. 1.—The alfalfa weevil: Adult. Enlarged. (Original.)

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[1] *Phytonomus posticus* Gyll.; order Coleoptera, family Curculionidae.

NOTE.—This bulletin describes the work and spread of the most dreaded pest of alfalfa in the United States. It is of interest in the region west of the Mississippi River, particularly Utah and the adjacent States.

IMPORTANCE OF THE ALFALFA WEEVIL AS A PEST.

This insect attacks Utah's most important crop. Alfalfa furnishes 80 per cent of the value of the hay and forage of the State, which in turn is 40 per cent of the value of all crops. The 1909 crop was worth nearly $6,000,000.[1]

About one-half of the annual yield is harvested in the first cutting and about one-third in the second. The damage to the first cutting ranges from slight depreciation of the quality of the hay to almost total loss, varying according to the rate of growth and the time of harvest; it may be estimated at 50 per cent. The damage to the second cutting, if no effort is made to prevent it, amounts to total loss. The menace to this State, therefore, involves one-half the yield, worth $3,000,000.

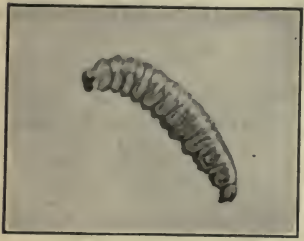
FIG. 2.—The alfalfa weevil (*Phytonomus posticus*): Larva. Much enlarged. (Original.)

Besides the loss represented by these figures, there is a less tangible but equally serious effect due to the peculiar relation of alfalfa to western agriculture. Because of its ability to revive after prolonged drought, to produce abundant crops for many years without reseeding, and to furnish a nearly complete ration for live stock, it has a very great value for a region where the water supply is scanty, reseeding expensive and difficult, and live stock an important and increasing source of wealth.

THE INFESTED DISTRICT.

The infested district (fig. 3) reaches north from Salt Lake City to Rosette, Utah; Strevell, Malad City, and St. Charles, Idaho; and Cokeville and Granger, Wyo. It extends south to Moroni and Oasis, Utah. These points lie near the rim of a circle about 100 miles from Salt Lake City. Eastward the weevil has gone only about 50 miles to the Uinta Mountains and westward an equal distance to the Salt Lake Desert.

SPREAD OF THE WEEVIL.

Both the outline of the infested district and the history of the spread show an average seasonal advance of about 10 miles per year since 1904 or 1905, when the insect was discovered by farmers at Salt Lake City. There are no isolated colonies distant from the main body, and there have been no long jumps in the movement. If wagons and railroad trains have carried weevils it has evidently been only for short distances. As has been predicted,[2] their spread has been largely by crawling and flight. The greatest progress has been along certain wagon roads, rather than in the direction of prevailing winds, railroads, or streams. This point is well illustrated by the road to St. Charles, Idaho. Here the insect has gone 100 miles along a main road, across mountain ranges, regardless of prevailing winds, and far from railroads.

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[1] Thirteenth United States Census.

[2] Utah Agricultural College Extension Department Bulletin No. 1, 1909.

That no one knows exactly how the weevils spread, may be inferred from the conflicting quarantine regulations designed by uninfested States to exclude them. Thus, Arizona forbids the importation of nursery stock; California requires its fumigation at origin and delivery and forbids packing with hay, straw, or rushes; Idaho differs from California in permitting the use of rushes; Montana requires official fumigation at the point of origin; Oregon forbids the use of rushes and forage plants as packing; Arizona prohibits the importation of fruits; Montana, the importation of both fruits and vegetables from April 1 to October 31, except such as are inspected at designated points by the State of Utah from August 1 to October 31. Arizona and Oregon

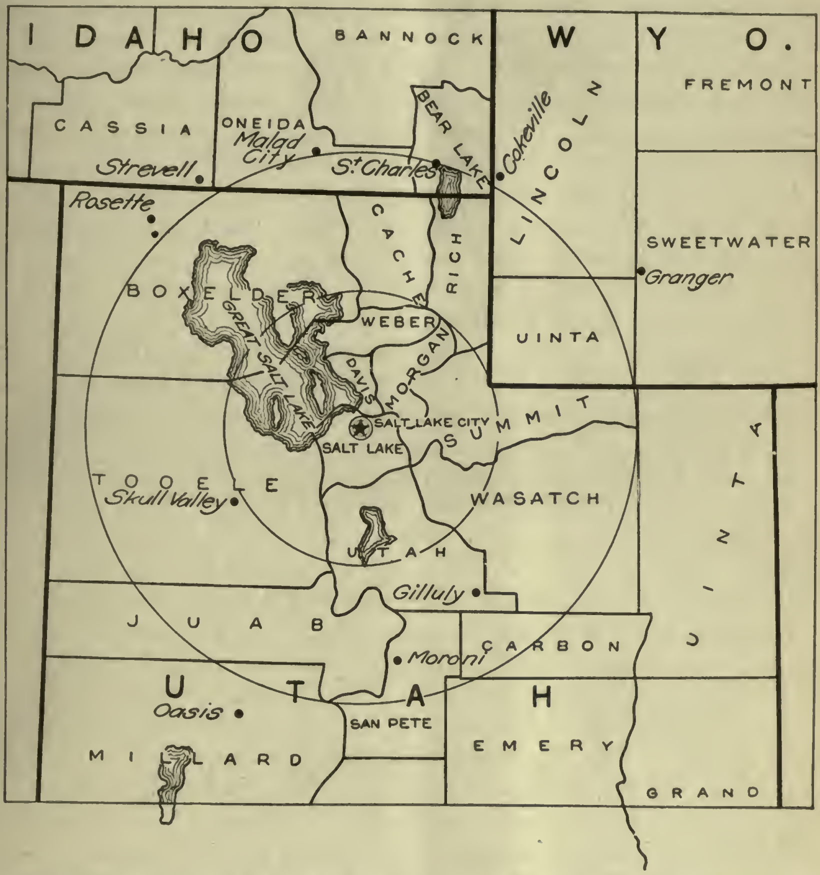

FIG. 3.—Map of portions of Utah, Wyoming, and Idaho, showing the district infested by the alfalfa weevil. The circles are 50 and 100 miles from Salt Lake City. (Original.)

prohibit the entrance of alfalfa seed; California and Idaho require it to be fumigated by an official after arrival; and Montana requires it to be so fumigated before shipment. Hay and straw of all kinds are barred by all five States. Bees in hives are refused admittance by California and Idaho; and Oregon requires that they shall not be packed in rushes, weeds, or forage. Household goods must be inspected before shipment into Arizona. Live stock can be shipped into Arizona only with the consent of the State entomologist and must be transferred to clean cars before crossing the line. California and Idaho prescribe that hay and straw must not be used in cattle cars, and Oregon forbids also grass and forage crops. Grain is barred from Arizona. Colorado, Wyoming, New Mexico, and Nevada have no restrictions on account of the alfalfa weevil.

In spite of the contradictory popular ideas of the means by which the alfalfa weevil travels, many facts which bear upon the question are definitely known. Live weevils do not occur in alfalfa seed, either before or after it is recleaned. They are seldom found in nursery packing of any kind, fruits and vegetables, or hay and straw used for packing, bedding, or feed, except under the following conditions: They are often found in green alfalfa fresh from the fields and in second-crop hay and potatoes which have been handled in contact with it; and they are found also in cured alfalfa hay, especially hay of the second cutting, in the stack, where some of them remain alive until the end of the following winter. They are found for several hours afterward in clothing which has been worn through infested fields in summer time, and sometimes remain even after the clothing has been packed in a trunk and shipped as baggage.

The occurrence of weevils in green alfalfa hay and new hay of the second crop is particularly important, because potatoes which are to be shipped are often hauled to the car upon a bedding of it to prevent bruising and are sometimes covered with it to protect them from the sun. This hay usually contains weevils, which crawl from the alfalfa to the sacks and are loaded into the tight refrigerator car, in which they often remain until it reaches its destination. Although no colonies have yet been started by this means, there is constant danger of it, which can be minimized by simply keeping the hay away from the potatoes.

Another important consideration as to the occurrence of weevils in new hay is that many people driving through the country in summer carry it for short distances as feed for their horses. The weevils may leave the hay as a result of the jar of travel, according to their habit; and that they do so is the more probable because no colonies have been found at any distance from the main territory, as would have happened if they were carried long distances by wagon. There is, however, a constant stream of traffic over certain main roads, composed of sheepmen, peddlers, and others bent on business or social visits to other localities, near or remote. The carrying of weevils by these people, even if it be but for a mile or two, amounts in the aggregate to a systematic relaying of the species over through routes. There seems, in fact, to be a relation between the localities where alfalfa from infested fields is carried in this way and the country over which the weevils have spread most rapidly.

No connection can be traced between the railroads and the actual spread of the alfalfa weevil; in fact, the advance of the weevils has been rather less rapid along some railroads than in certain regions remote from them. The weevils occur rarely in baggage, express, and freight cars, and somewhat more often in passenger cars and refrigerator cars containing potatoes which have been handled with fresh second-crop alfalfa hay. Although there has been a large volume of unrestricted passenger traffic from the infested region during the past 12 years, no colonization of weevils has resulted; and although weevils have traveled in potato cars as far as Denver, Colo., Rock Springs, Wyo., and Butte, Mont., and many cars of potatoes which doubtless carried weevils were shipped throughout the Western States, no colonies have been started by this means.

The transportation of weevils on railroad trains and wagons is little affected by the flying of the species. It seemed reasonable at an early period of the investigation to believe that a beetle which flies abroad in the summer would alight upon various commodities and vehicles and be carried for great distances, but such is not the fact. Weevils are rarely found on trains or wagons except in cases where new hay is involved. The flight of the weevil not only plays a small part in its distribution by wagons and trains, but it is less general and extensive than it was once supposed to be. All records which are definite and authentic show only small numbers of the weevils in flight at any time. Reports dealing with immense numbers swarming in the air usually mention no specimens at all as actually caught, identified, and counted. They do not agree with the observations of this bureau, and many of them are probably based, by mistake, upon some other insect, such as the dung-beetle, Aphodius, which resembles the weevil in appearance and is always present in the air in larger numbers than the latter.

There is no evidence that the weevils ever fly for the purpose of seeking fields of alfalfa, either new or previously infested, or to find hibernation quarters. The most plausible theory is that their flight is caused by a rise in temperature, as are many activities of the lower animals. So far as can be learned, this flight is at random. It takes some of the weevils into new fields.

The crawling of the larvæ is unimportant as a method of spread, being limited to a journey of a few feet from one field to another, but the crawling of the adults is an important matter. During the cold weather of spring and fall a day's journey of an adult weevil is only a few inches, but during the warm months the adults crawl during the greater part of the day or, in July and August, of the night. Although they use up much of their energy in climbing up and down plants, and into and out of crevices in the ground, so that it is largely wasted so far as progress is concerned, a little of it happens to lead to new fields. There is no general movement by crawling, any more than by flight, from the fields to the ditch banks, fence rows, and similar places, or from such places to the fields, at any time. The crawling is most important, as has been shown, in bringing weevils into hay and so into traffic, which probably takes them somewhat farther than they could go without help.

During the 12 years that the alfalfa weevil has been in America it has spread into new territory very slowly and has agreeably disappointed those who feared that it would extend rapidly over all the alfalfa-producing regions of the continent. Its progress is so slow that there is hope of providing control methods for new climates and conditions as fast as these are encountered. There is hope also that the pest will not prove equally injurious under all circumstances. It is much less harmful in Europe than in America, owing apparently to climatic and industrial conditions, and it multiplies more slowly and does less damage in the higher altitudes in Utah and Wyoming than in the lower valleys. Nevertheless, it is possible that eventually every section of the country will have to consider, first, the problem of keeping the insect out of its boundaries, and later, the problem of growing alfalfa in spite of the weevil, or finding

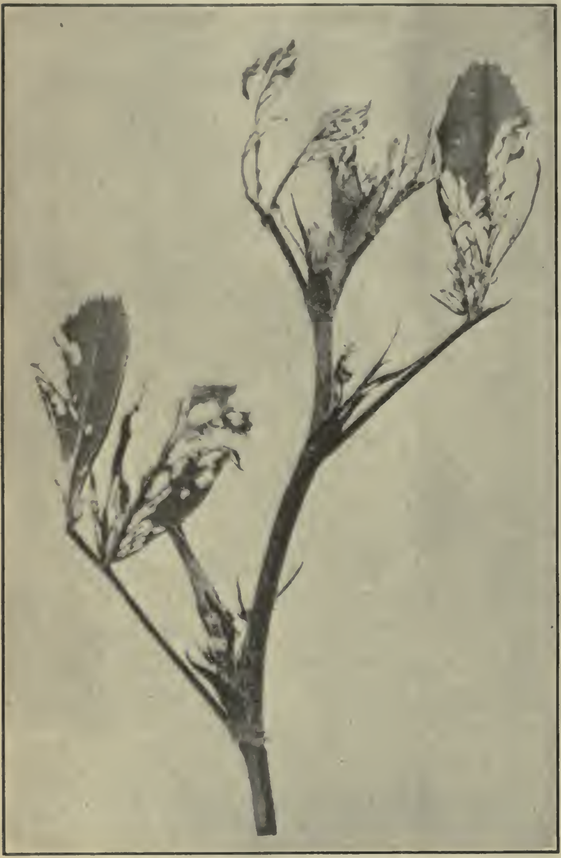

FIG. 4.—The alfalfa weevil: Work of the larvæ. (Original.)

a substitute for that valuable crop. It is therefore particularly desirable that farmers in the western mountains and plains should learn the appearance of the different stages of the weevil and be prepared to protect their crops.

DESCRIPTION OF THE WEEVIL IN ITS DIFFERENT STAGES.

THE FULL-GROWN LARVÆ.

The insect is most easily discovered, during the early years of its presence in new fields, in the form of the full-grown larva (fig. 2). It is then a green wormlike creature one-fourth of an inch long, with a black head and a faint white stripe down the middle of the back, and it feeds upon the leaves of the alfalfa mainly during late May, June, and early July. It can be found by sweeping the tops of the plants with an insect net, or by looking for the notches in the leaves where it has fed. When the larvæ are numerous they destroy most of the tender growth (fig. 4), causing the tops to appear white and making the field look at a distance as if frostbitten.

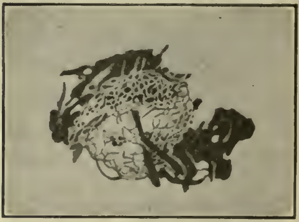

FIG. 5.—The alfalfa weevil: Cocoon attached to dead leaves. Much enlarged. (Original.)

THE NEWLY HATCHED LARVÆ.

The newly hatched larvæ are harder to find. They are only about one thirty-second of an inch long and remain hidden in the partly unfolded tips of the plants, where they are not easily seen or caught by the net. Their color is yellowish green, excepting the head, which is black. The color changes to green at the first molt, or shedding of the skin, and there is little change except in size during the two or three molts which follow, varying in number with the season of the year in which the larval life is spent.

THE PUPÆ AND COCOONS.

The pupal form is the one in which the change from the larva to the adult takes place. The pupa is contained within a delicate, oval, netlike cocoon (fig. 5), woven of a few white threads and attached, sometimes to the lower part of a green stem, sometimes to rubbish on the ground, and often to the inner side of a curled dead leaf. The pupa within this cocoon is somewhat like the larva in color, but more like the adult beetle in form, becoming still more like it in both respects as it approaches maturity.

THE ADULTS.

The adult is harder to find than the larva, but is present in the field throughout the whole year instead of the summer only. It is an oval brown beetle, three-sixteenths of an inch long, with a prominent snout projecting downward from the front of the head. The color of old, weathered specimens is nearly black, owing to the dark ground color revealed by the shedding of the brown and yellow scales which at first clothe its upper surface. The adult stays close to the ground during early spring and late fall, but climbs about in the tops of the plants during the warm season. It is not readily seen by one walking through the fields, because it habitually drops to the ground when disturbed, and its color helps to make it invisible. It can be captured during the warm weather by sweeping the plants with a net and during the cooler spring and fall weather by sitting quietly in the field and catching it when it moves on the ground. In the winter it can be found by digging about the crowns and roots of alfalfa plants.

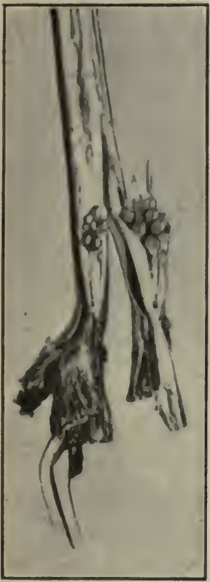

FIG. 6.—The alfalfa weevil: Eggs in split green stem. Enlarged. (Original.)

THE EGGS.

The eggs (fig. 6) are less conspicuous than the larvæ and adults, because they are usually concealed within the stems of the plants; but the holes in which they are placed are found in large numbers by examining the green stems during May and June, and in smaller numbers as early as March and as late as December. The eggs are small, oval, shiny globules, bright yellow when first laid, but dingy after a few days when incubation has begun, and adorned during the latter part of the incubation period with a black spot where the head of the little larva shows through the transparent shell. A few eggs, some of them infertile, are laid on the outside of the plants, and more in the weeds and grasses which grow in the field. Late in the fall and early in the spring there are many in the dead stems on the ground.

When an alfalfa grower outside the territory known to be infested finds in his field any insect which he suspects to be a form of the alfalfa weevil, he should send it to the Bureau of Entomology field station at Salt Lake City, Utah, to be identified. If it proves to be the alfalfa weevil, it is important that work should begin without delay, so that the measures that will be effective in controlling the pest under the new conditions may be learned. This work requires study of the traveling, feeding, mating, and egg-laying habits of the insect; of the effect upon it of climate, crop conditions, and farm operations; and of the agricultural conditions of the region, in order that the conditions favoring the growth, increase, and work of the weevil and the conditions necessary to destroy it or hinder its work may be ascertained. So far as these things are already known in regard to the country now occupied by the weevil they are here set forth.

HABITS OF THE WEEVIL.

WHERE AND HOW THE WEEVILS PASS THE WINTER.

When cold weather comes on the adult weevils creep down close to the ground and into crevices and spend the winter there. Some ditch banks and other uncultivated places which are strewn with the litter of dead vegetation harbor many of them, but these numbers are an insignificant part of those which remain in the fields and deposit eggs the following spring. Burning the grass and weeds in such places, therefore, while desirable in itself, gives practically no protection to the crop in neighboring fields.

Many weevils die in the fields during zero weather, but milder winter temperatures seem to have little effect upon them. Since bare ground freezes more than that which is covered by snow, it is sometimes advisable to cultivate the field in the fall, so that the snow which falls upon it may melt and expose the weevils as much as possible to the cold.

Owing to the fact that most of the weevils spend the winter on the ground in the fields, it is possible to kill them by flooding the field with muddy water and thus covering it with sediment.

There is no definite hibernation in this species. The adults are quiet when it is cold and active when it is warm. A female taken from the frozen fields will feed immediately and oviposit in a few hours after being brought into a warm room.

EARLY SPRING ACTIVITY OF THE WEEVILS.

The readiness with which the weevils resume their activities when subjected to warmth has an important bearing upon control measures. The weevils lay scattered eggs in early spring, many weeks before the regular laying season, and deposit numbers of eggs in the dry stems on the ground even before they begin climbing up the green plants and feeding upon them. Larvæ hatching from these eggs, with those from eggs laid under similar circumstances the previous fall, sometimes attack the plants in numbers large enough to cause serious injury to the crop before the majority of the eggs have been laid, particularly in years when there is an early spring. This early activity must be taken into account in any attempt to protect the first crop.

The fact that the adults feed rather freely for several weeks in early spring while the plants are small is the basis for attempts to destroy them by spraying with arsenical poisons. There is no danger of poisoning the live stock which may eat the hay, because the plants are too small at the time of spraying to hold much poison, and this early growth forms but a small portion of the hay crop. The amount of poison contained in hay from fields which have been sprayed only three weeks before cutting is too small to have any effect upon the most sensitive animals. The feeding of the adults is done chiefly after the usual time for the dormant spraying of orchards and before the early codling-moth spraying, and therefore the work on the alfalfa fields need not conflict with either of those operations. Aside from its relation to spring spraying, this early feeding of the adults is chiefly important in that it gives the spores of Sackett's disease a chance to lodge within the tissues of the plant.[1] The damage caused by this blight is sometimes as serious as that done by the weevil larvæ themselves and is generally confused with it.

EGG LAYING OF THE WEEVILS IN LATER SPRING.

After feeding for several weeks, running about over the ground, depositing eggs in dry stems, and flying a little, the adults deposit large numbers of eggs in living stems. When the spring opens early they begin egg laying gradually, and the earliest eggs may hatch before the majority are laid. After a late spring the egg laying begins abruptly. In either case it is usually ended before June 10, and if the eggs can be destroyed up to that date, the attack of the larvæ will be prevented for the year. This can be done by pasturing the first crop so as to destroy the eggs after they are laid and before they hatch, or, at latest, while the larvæ are still small enough to cling to the leaves and be swallowed. This is the basis of the pasturing method and of a similar method of destroying the eggs and at the same time utilizing the first crop by cutting the alfalfa green and feeding it as a soiling crop.

WORK OF THE LARVÆ IN THE FIRST CROP OF ALFALFA.

If none of the treatments mentioned has been used, the larvæ appear in large numbers about the last week of May, or earlier if the spring has been favorable, and eat the leaves, especially on the young shoots, so rapidly that the plant is unable to outgrow the injury. At this stage, or a little earlier, it is necessary to cut the crop regardless of its condition, in order to prevent severe and perhaps total loss. The results of spring cultivation show at this time. The fields which have been cultivated grow earlier and produce a larger yield before cutting becomes necessary than do those which have been neglected. A few of the larvæ have finished feeding and spun their cocoons before even an early cutting. Most of the others spin during the month of June, though a few late larvæ are abroad in the field until winter.

When the first crop is removed, if the ground is dry and the weather clear and warm, many larvæ, pupæ, and adults die as a result of exposure to the heat of the ground. This mortality is increased if the ground is cultivated in such a way as to fill the cracks, crush the clods, and scrape off all remaining vegetation. This, in turn, is more easily accomplished if the soil has been kept in good condition by manuring and cultivation. The killing of the insects by heat is the foundation of the "brush-drag" treatment.

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[1] O'Gara, P. J. Bacterial blight of alfalfa in Salt Lake Valley. *In* Science, n. s., v. 39, no. 1016, pp. 905, 906. 1914.

SUMMER FLIGHT OF THE ADULTS.

The heat of the soil is also probably an important cause of that increase in the activity of the adults called the summer flight, which is greatest during the dry, hot weather beginning in June and ending in August. This flight accounts for the presence of many adults in grassy places and orchards, where they alight and find protection from the heat. It helps to restock fields in which the weevils have been killed and makes it necessary to repeat the treatment year after year, and on the borders of the infested district it contributes to the spread of the pest. The summer flight is not a general movement of the weevils from the fields to seek more suitable hibernation places elsewhere. There is no such movement, and virtually all of the weevils spend the winter in the fields.

WORK OF THE LARVÆ IN THE SECOND CROP.

If no treatment is given the infested field after haying, the larvæ which have been feeding upon the first crop gather upon the buds of the stubble, and although many have been killed by the heat of the earth after the cutting, there are still enough to prevent the sprouting of the second crop for a time nearly equal to its usual period of growth. By that time most of them have finished their feeding and growth and have gone into the pupal stage, and there is consequently no attack upon the later growth.

ACTIVITIES OF THE NEW GENERATION OF WEEVILS IN SUMMER AND FALL.

At the time of cutting the second crop the fields are full of weevils of the new generation, and there are usually many more weevils in the second-crop hay, which is cut at this time, than in that of the first and third crops. Their activity is greater at night than by day, and this condition continues until the cool nights of September begin. As autumn progresses, they haunt the plants less and less and fortunately are nearly all on the ground before the thrashing of the seed begins. No live weevils have ever been found in alfalfa seed.

About one-half of the females of the new generation of beetles are ready to deposit eggs by the middle of October, and egg laying, chiefly in dry stems, goes on for about a month after that time. Few of these eggs hatch before winter, and some of them hatch the following spring and probably take part in the early attack upon the first crop.

These habits of the weevil and the relations between it and the crop, the climate, and the country, comprise most of the facts for which a practical use has been found. Upon them are based all effective plans for preventing its ravages and retarding its spread.

RECOMMENDATIONS FOR THE CONTROL OF THE WEEVIL.[1]

SILTING.

Weevils can be killed in late winter or early spring by irrigating the fields with very muddy flood water and so burying them under a deposit of fine mud. This is practicable only where the irrigation system is without a settling reservoir, which is in itself an undesirable condition, but in the few cases where it can be applied the process is simple and inexpensive and the results good.

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[1] In the field tests of spring and fall cultivation and the dust-mulch treatment the Bureau of Entomology has had the cooperation of the entomological department of the Utah experiment station.

SPRING CULTIVATION.

Alfalfa fields in a weevil-infested region should be cultivated thoroughly in the spring with the spring-tooth harrow, disk harrow, or a similar tool, provided the crop is valuable enough to warrant the expense of the operation. Under conditions where cultivation is especially desirable, as where water is scarce or the soil does not naturally retain moisture well, this may increase the amount of the first crop as much as 50 per cent. It will cost from 60 cents to $1.25 per acre. In nearly every case it will be necessary to go over the field at least twice; and if the soil is in such condition that a double harrowing does not pulverize the soil and kill the weeds and grass, systematic manuring, cropping, and cultivation to improve the soil are desirable. Spring cultivation has no appreciable effect on the weevils, but merely hastens the growth of the alfalfa so as to give a larger yield when the attack of the larvæ in May or June makes early cutting necessary.

SPRING SPRAYING.

As soon as the weevils begin feeding upon the leaves of the plants, which usually happens early in April, the field may be sprayed with from 50 to 100 gallons per acre of a mixture of arsenite of zinc and water, in the proportion of 4 pounds of powder in 100 gallons. Owing to war conditions it may be impossible to obtain this poison at the present time. Arsenate of lead has not so far proved successful as an early spring spray.

On several occasions when it was intended to spray fields in early spring, circumstances prevented it, and the spray was applied about May 1, after many larvæ had hatched from the eggs and attacked the crop. In several of these cases the results were good, although the amount of foliage which must be covered is larger at this time than in early spring. Arsenate of lead, in the usual orchard strength of 4 pounds to 100 gallons of water, was as effective at this time as arsenite of zinc.

The attachment which is recommended for use with the hand-pump or gasoline-engine outfit for spraying alfalfa fields resembles the potato or beet sprayer. It is a horizontal pipe, 3 feet above the ground, fastened across the back of the truck of the power sprayer (fig. 7) or the wagon in which the hand pump is carried, and stiffened by lashing to a 2 by 4 scantling as long as the pipe itself. To provide for the attachment of the supply hose from the pump and the nozzles which distribute the liquid, the pipe is built up of 30-inch pieces of one-half inch galvanized iron pipe, coupled by T's, except at the middle, where a cross is used, and the ends are fitted with L's. Unless reducing T's, L's, and cross can be obtained, a ½ inch by ¼ inch bushing must be used for each nozzle, and in either case the attachment is made by means of a short one-fourth inch nipple. The hose lead from the pump is attached by means of a hose coupling. There should be a stopcock between the hose coupler and the main pipe to cut off the flow and maintain pressure whenever it is necessary to stop spraying in order to clean or repair nozzles.

The number of joints of pipe and nozzles to be used depends upon the capacity of the pump. A 2½ horsepower engine and a good pump will supply seven nozzles of the eddy-chamber type, with $\frac{3}{64}$ inch holes in the disks, and maintain a pressure of 150 to 200 pounds. Some hand pumps will hardly supply three nozzles The nozzles are likely to become clogged, no matter how much care is taken to have the solution and the apparatus free from foreign particles. In addition to such precautions, therefore, it is wise to use nozzles provided with direct cleanouts at a slightly higher cost, as the time saved in operation makes up for the extra cost. Before work is begun, the tank, pump, hose, iron pipe, and nozzles should be thoroughly cleaned to remove particles of rust, sediment, and other foreign matter. The water and poison should be screened through fine brass strainer cloth. Attention to these details makes the difference between economical and expensive spraying, as clogging of the nozzles means costly delay for the entire outfit.

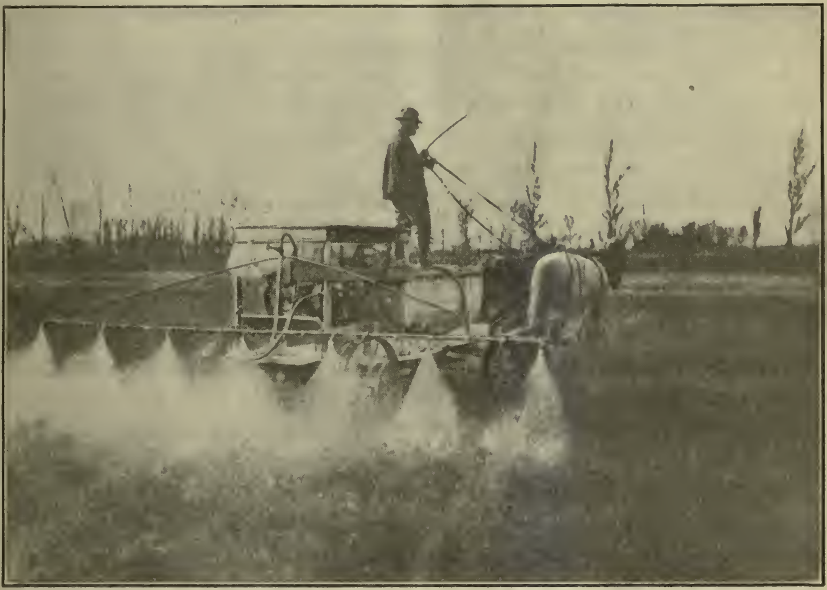

FIG. 7.—Alfalfa sprayer with power pump, in use against the alfalfa weevil. (Original.)

The cost of spraying with a power sprayer will depend largely upon the distance water must be hauled. It should range from 70 cents to $1.05 per acre when the usual price is paid for poison, the use of machine, the services of the operator, and the labor of the team and driver. Spraying does not take the place of spring cultivation in improving the condition of the soil and hastening the growth of the crop, nor does cultvation take the place of spraying in preventing the work of the weevils. The two operations are independent of each other, and in many cases both are desirable.

PASTURING.

If spraying is out of the question, the first and second crops may be protected by destroying the eggs after they have been laid in green stems, or the small larvæ after they have hatched and begun feeding in the tips, by pasturing the field. The success of this as a method of killing the insects depends upon managing the grazing in the right way and continuing it until most of the eggs have been laid; that is, until after the usual cutting time of the first crop. Instead of being pastured over the entire area at once, the field should be divided into two or three lots, with fencing suitable for the kind of live stock that is to be used, and the lots should be pastured alternately, so that each, after being eaten down close to the ground, will have a chance to grow up before the animals are turned in again. The number and size of the lots should be proportioned to the producing power of the field and the number of animals to be pastured, so that each lot may be grazed close to the ground about once in two weeks.

The pasturing may begin as early as the growth of the alfalfa will permit, and the change from each lot to the next should be made as soon as the larvæ which have developed in the next lot begin to feed upon the plants. On the other hand, the change should not be made until the lot which is being pastured has been grazed close. The number of animals which are necessary is regulated by these requirements, varying at different times with the rate of growth of the alfalfa. It may sometimes be advisable, when the stock has eaten most of the lot clean but allowed the plants to grow tall in certain spots, to mow these spots rather than to compel the animals to graze them.

The work may be considered finished as soon as most of the weevil eggs have been laid, which means a little later than the usual cutting time of the first crop. A good, practical method of deciding this question is to continue the pasturing until the lot containing the oldest growth continues free from signs of larval feeding past the time when the appearance of larvæ is to be expected, according to the experience of the season.

The area which can be protected from the weevils in this way is limited by the amount of live stock available. Three and one-half acres of rather poor alfalfa handled in this way will support from forty to fifty 60-pound hogs, or a corresponding number of other animals.

According to the statements of agricultural experts, this way of preventing weevil injury deserves more notice than its usefulness for that purpose alone warrants, owing to the fact that, when combined with the proper feed of grain, alfalfa pasture furnishes an economical method of fattening live stock. Many farms would probably be more profitable if their management centered about the pasturing of stock on alfalfa, with the growing of enough other crops to provide grain and forage throughout the year. This is a matter that each must work out for himself to suit local conditions. Wherever the pasturing method is practicable it will solve the alfalfa-weevil problem.

SOILING.

Cutting the alfalfa green two or three times during the season and feeding it gives results similar to those of pasturing. It is especially suitable for dairy farms.

THE DUST MULCH.

If the weevils have not been killed earlier, they may be destroyed after removing the first crop by removing nearly all the vegetation, crushing the clods, and filling the cracks so as to expose the entire surface of the field to the sun. This is best done by such cultivation as will cover the field with a dust mulch, the dust being an additional means of killing the weevils which escape the heat of the ground. Success depends largely upon doing the work when the ground is dry and the weather warm and bright. It should not be attempted in cold, cloudy, or wet weather, nor soon after irrigation.

Dragging the field twice with a brush drag is sufficient if the soil is already mellow, but most fields need one or two cultivations with the disk or the spring-tooth harrow, and some grassy fields with heavy soil can not be put into the best condition to kill weevils until after they have been systematically improved for several years. A tool which is used instead of the brush drag in Salt Lake Valley is built by stretching several layers of heavy woven-wire fencing under an ordinary spike-tooth harrow with the teeth laid flat, and adding enough weight to pulverize the soil.

The dust-mulch method has practically no value as cultivation, since it must be followed by irrigation, which packs the surface dirt and restores it to the condition which obtained before cultivation. Its value depends entirely upon the fact that it kills the insects and so permits the second crop to grow. It is open to the objections that it requires time and the labor of men and horses during the busiest season of the year and that it stirs up the stones on rocky fields.

SUMMER SPRAYING.

Many farmers have sprayed the stubble after removing the first crop, with results about equal to those of the brush-drag treatment. The same apparatus can be used as for the spring spraying, but the usual method has been to distribute the spray through two leads of hose and two Bordeaux nozzles, each handled by a man who walks behind the outfit or rides upon it and covers the ground as evenly as possible and as far as he can reach with the spray rod. Both Paris green and arsenate of lead, in the usual orchard strengths of 1 pound and 6 pounds, respectively, per 100 gallons of water, have been successful.

This treatment is more rapid than the brush-drag method, but it requires special machinery. For orchard districts it is very promising.

PUDDLING.

Several farmers have protected the second crop by dragging the stubble, while it is still wet from irrigation, with the land leveler or the clod breaker. This process embeds the insects in mud, in which they perish, and effectually prevents them from attacking the sprouts. It is easier than the dust-mulch method, but it is harmful to the soil and is not recommended.

PREVENTION OF SPREAD.

Equally important with the problem of coping with the weevil in the fields is that of preventing its spread into new territory or, at least, since that may be impossible, of giving it as little help as possible. Aside from the consideration that the prosperity of each section depends largely upon that of other sections, the spread of the weevil from one district to others is a distinct detriment to the former as well as to the latter in that it increases the distance from which hay for feeding purposes must be shipped and consequently increases its cost.

All commodities which are to be shipped or hauled out of infested territory should be kept from contact with growing alfalfa, and they should at all times be kept away from new alfalfa hay, particularly that which has been cut during July and August.

SUMMARY OF RECOMMENDATIONS.

The first and second crops of alfalfa can be protected from the alfalfa weevil by spraying the young growth in early spring, by proper pasturing, or by cutting and feeding the crop before the eggs in it have hatched, and in a few cases by covering the field with silt in early spring. The growth of the alfalfa can be stimulated and a larger yield obtained by cultivating the field in the spring. The second crop can be protected by spraying the stubble or by the dust-mulch treatment.

Care should be taken to avoid spreading the weevil by shipping out of the infested district either new alfalfa hay or articles which have been in contact with it or with growing alfalfa.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 742 JUNE 9, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

THE WHITE-PINE BLISTER RUST.[1]

BY PERLEY SPAULDING, *Pathologist, Office of Investigations in Forest Pathology.*

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INTRODUCTION.

The white-pine blister rust is a destructive disease of the so-called white pines, that is, pines which bear their needles in bundles of five each. It has caused much damage in some of the countries of northern Europe. It is caused by a parasitic fungus (a plant organism) similar in many respects to the fungi that cause wheat rust and cedar apple rust. Like those diseases, it requires two distinct kinds of host plants in order to complete its entire life. These are (1) the 5-needle pines and (2) the wild and cultivated currants and gooseberries.

This serious disease of our white pines came to us from Europe in imported white-pine seedlings. It is now known that comparatively small lots of such diseased seedlings were imported as long ago as 1900, or even earlier; but in the year 1909 immense numbers of such seedlings were brought into the country and were largely distributed before the presence of the disease was discovered. In this way the

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[1] This publication is designed to be spread open at the colored plate, so as to serve as a poster when desired.

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disease was introduced into the States of New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, New Jersey, Ohio, and Indiana. The disease is now known to be present in the States of New Hampshire, Vermont, Massachusetts, Connecticut, New York, and Pennsylvania. Owners of planted 5-needle pines in all States should watch for indications of this serious disease.

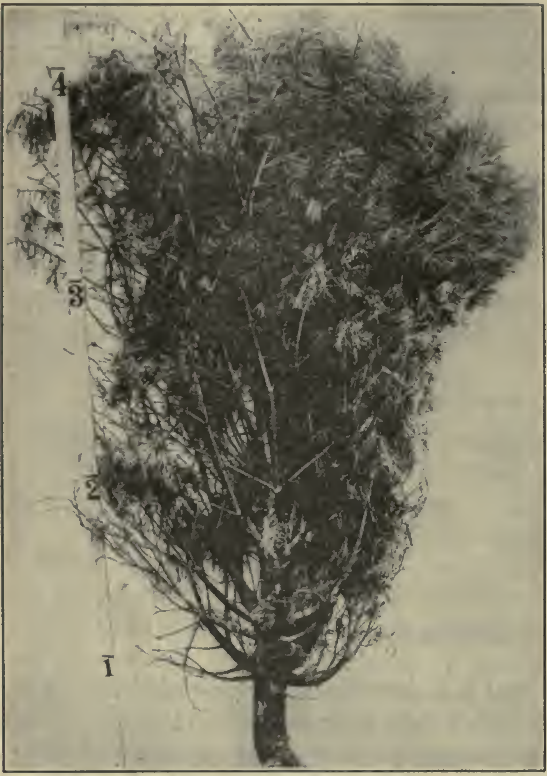

FIG. 1.—White-pine tree about 10 years old dying from the effects of the blister rust. The measure indicates the height of the tree in feet. Just above the 1-foot level is a girdle of dead, cracked bark. Directly above the dead bark are numerous white blisters on the edges of the living bark. The tree is badly stunted in growth. (Photograph furnished by G. C. Atwood.)

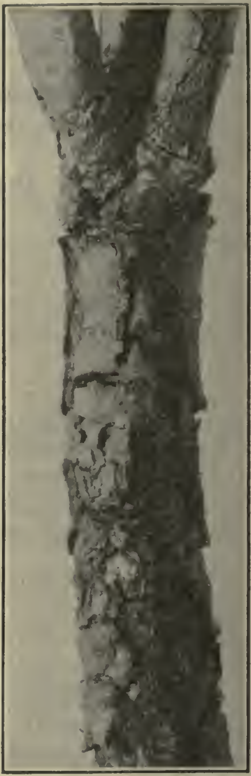

FIG. 2.—Trunk of a white-pine tree about 10 years old which has borne blisters of the blister-rust fungus in previous years. Note the heavy scales of dead bark on a tree which at this age ought to have smooth bark. (Slightly less than life size.)

WHAT TO DO ABOUT WHITE-PINE BLISTER RUST.

WHAT TO DO ABOUT WHITE PINES ALREADY PLANTED.

The white-pine blister rust [1] came into this country from Europe in nursery stock and in no other way. Any white pines, stone pines, or other 5-needle pines[1] that were imported from Europe are liable to have the disease.

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[1] The disease commonly known as white-pine blister rust is caused by a fungous parasite known technically as *Cronartium ribicola* Fischer (*Peridermium strobi* Klebahn).

Therefore, at any time of year—

(1) Find out definitely the source of your pines. Were they raised from seed in this country or bought of some one who might have imported them? Get a definite statement from the man who furnished them to you. If he obtained them from another person, find out from the latter whether he raised them from seed or not. In short, trace your trees definitely back to the nursery where they were grown from seed. Do not accept an evasive reply. If the source of your pines can not be determined or if they prove to have been imported, consider them under suspicion until you can have an expert inspection made. The Bureau of Plant Industry, on application embodying a statement of such facts as are known to the owner or observer, will make an inspection or secure a competent inspection free of charge.

(2) Inform your neighbors about this disease. Find out whether their pines were grown in America or imported. Tell them if you think you see evidences of the blister rust on their trees, and advise them what to do. Diseased trees on your neighbor's land are a source of danger to you. Post this publication in a conspicuous place, such as the railroad station, post office, town hall, and grange hall. Tell your neighbors to ask the United States Department of Agriculture for Farmers' Bulletin 742, if the disease is on their trees or they are interested in it. Secure more copies yourself if they can be well distributed.

(3) If you can not prove that your pines were grown in America from seed, look at all times of the year for dead trees, dead tops, or dead side branches on the pines. If any are found, look for a girdle of dead, cracked bark below the dead part, as shown in figures 1 and 2. If a girdle is found, look for the pycnidial drops on the living swollen bark adjoining the dead portion. (See fig. 3, showing them on a tree not yet girdled.)

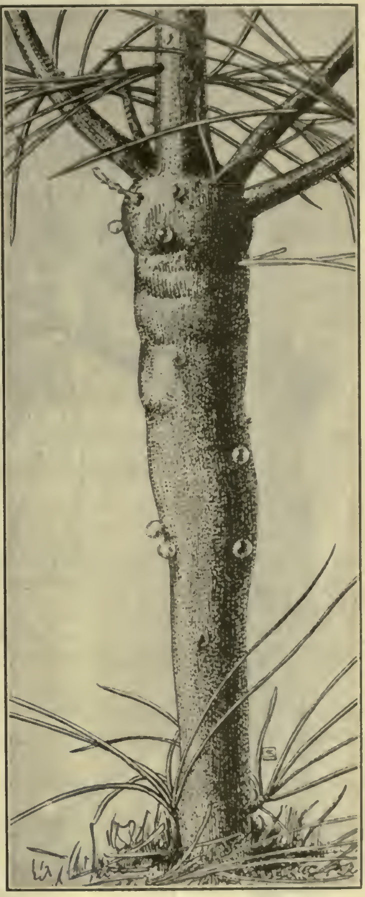

FIG. 3.—A young white-pine tree, showing the swelling and pycnidial drops of liquid caused by blister rust. (Life size.)

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[1] The scientific and popular names of the 5-needle pines of the world, exclusive of the different varieties, are here given for the convenience of nurserymen and others who may wish definite technical information: AMERICAN.—*Pinus strobus*, white pine; *P. monticola*, western white pine; *P. lambertiana*, sugar pine; *P. flexilis*, limber pine; *P. albicaulis*, white-bark pine; *P. strobiformis*, Mexican white pine; *P. balfouriana*, foxtail pine; *P. aristata*, bristle-cone pine; *P. cembroides*, piñon pine. FOREIGN.—*Pinus excelsa*, Himalayan white pine; *P. peuce*, Balkan pine; *P. armandi*, Chinese white pine; *P. parviflora*, Japanese white pine; *P. cembra*, stone pine; *P. koriensis*, Korean pine. Some of the more important varieties which are included in the foregoing species are *Pinus nepalensis*, *P. scipioniformis*, *P. mastersiana*, *P. pentaphylla*, *P. morrisonicola*, *P. formosana*, *P. pumila*, *P. mandschurica*, *P. sibirica*, and *P. coronans*.

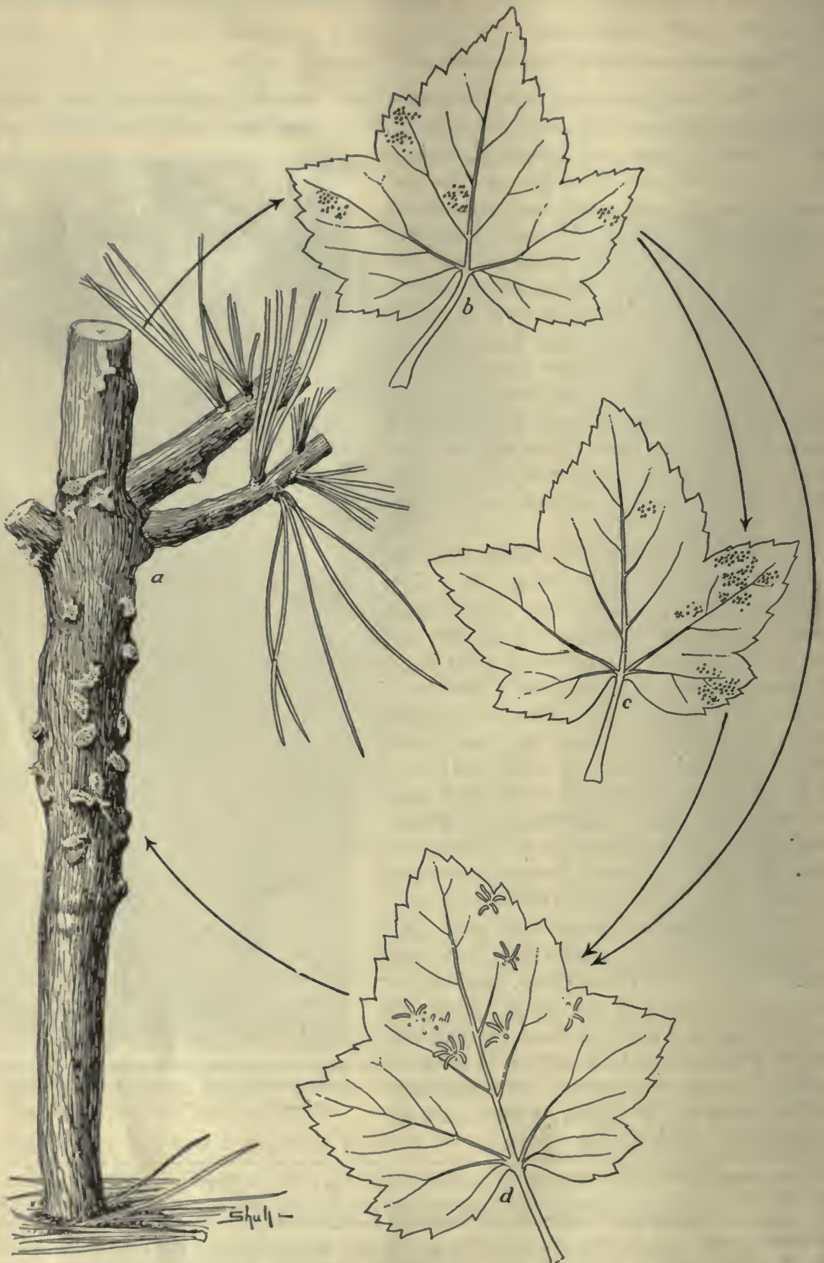

FIG. 4.—Diagram indicating the life circuit of the causal fungus of the white-pine blister rust. *a*, Blisters on pine in May and early June, from which the disease spreads to currant or gooseberry leaves and produces the early summer stage, *b;* thence it may spread to another currant leaf and produce there a second crop of the early summer stage, *c*, or it may produce the late summer stage, *d;* in this stage, in the fall, it infects neighboring white pines, which may or may not include the pine (*a*) which bore the blisters that started the outbreak the preceding spring.

At particular times of the year, look for the different stages of the disease, as follows:

Last of April to middle of June.—Search for blisters on planted pines. (Pl. I, *A*, fig. 1, and fig. 4, *a*).

June 1 to fall of leaves.—Search on leaves of all wild and cultivated currants and gooseberries for the yellow, summer stage of the disease. (Pl. I, *B* and *C*, and fig. 4, *b* and *c*). Pay special attention to cultivated black currants and to the flowering or yellow currant.

August 1 to fall of leaves.—Search on the leaves of wild and cultivated currants and gooseberries for the brown-hair or autumn stage of the disease (Pl. I, *D*, and fig. 4, *d*).

If it is believed that the disease is found, get an expert at once to verify your opinion. Do not destroy trees or bushes until this is done, as such destruction may not be necessary.

When advised by a competent person to destroy certain trees or bushes, do so at once. Delay may mean much more damage. An owner refusing to take the necessary measures to control this disease will be injured first and most severely by the future progress of the outbreak.

HOW TO BUY WHITE-PINE STOCK FREE FROM BLISTER RUST.

Buy 5-needle pine stock only when a written guaranty is furnished by the nurseryman in the following form or its equivalent:

I, ..., do hereby guarantee that the ....
[Name of nurseryman.] [Number of trees.]
trees of .... pine furnished to .... were grown under the
[Kind of pine.] [Name of buyer.]
following conditions:

1. They were raised from seed in my own nurseries.
2. My nurseries contain no imported 5-needle pines or imported currants or gooseberries.
3. My nurseries and the neighborhood for 300 yards distant have no white-pine blister rust present now and have always been free from white-pine blister rust on 5-needle pines or on currants or gooseberries.

(Signed) ——— ———.

Such a guaranty will insure the securing of stock free from this disease. Any essential modification of this form will leave loopholes for evading the purpose of the guaranty.

This has absolutely no connection with the usual certificate of inspection made by a State officer. The inspection certificate alone is useless, so far as the blister rust is concerned, as the disease in its dormant stage can not be detected by inspectors.

DANGER FROM THE WHITE-PINE BLISTER RUST.

The white-pine blister rust is a disease which finally kills the attacked trees or parts of trees. If the trees are attacked while relatively young, that is, 25 years of age or less, it is extremely likely that the entire tree will be killed. If the tree is older than this when attacked, branches and possibly the top central shoot will be killed. Of course the loss of a few side branches is a small matter to an old tree unless it is an ornamental, but if the disease is present in abundance in proximity to such a tree for a number of years, that tree is likely to have every one of its lateral branches, as well as the top central shoot, attacked and finally killed. In this way the disease may kill the largest tree, and such instances are known in certain localities in Europe where this disease is very prevalent. The great damage, then, that the white-pine blister rust is likely to do at first is to young reproduction or to young plantations of white pines. But after it has become well established in any locality there can be no doubt that older and larger trees may be seriously crippled if not killed by it. In Europe, where this disease has been known for 60 years, it has attacked the stone pine, the Himalayan white pine, the Roumelian white pine, the eastern white pine, the sugar pine, the western white pine, and the limber pine. These are all 5-needle pines. Many of the so-called hard pines, having leaves in twos and threes, have been exposed to infection in Europe, but have never taken the disease. This shows that only the 5-needle pines will take it. There are 12 American 5-needle pines and 9 foreign ones. (See footnote, p. 3.) Any of these species may take this disease. The foreign species are of importance, as they may be cultivated in this country for ornamental purposes.

DANGER IN THE EASTERN STATES.

In the Eastern States the danger threatened by this disease is most important with respect to the eastern white pine. It is estimated that the valuation of the present stand of mature eastern white pine is approximately $186,000,000. This pine is of great importance, aside from the value of the present mature stand, because it is used in fully nine-tenths of the reforestation work in the Northeastern States. Moreover, within the area worst affected by the gipsy moth, the forests are being converted into white pine as rapidly as possible, because this species is by far the most valuable one which is not seriously injured by this insect. More than this, the white pine, in many sections at least, is much the most valuable tree now available for future forests. Its loss would be a real catastrophe, for no other tree can take its place.

The crisis with this disease is already upon the Northeastern States. Most serious and extensive outbreaks are known to have occurred in 1915. If not promptly stopped from spreading farther, there will be no hope of coping with it unless public opinion becomes very earnestly aroused in the near future. Complete authority must be given the State officials to compel unanimous action throughout the infected areas, or this disease will surely escape and become a permanent menace to the entire white-pine stand of the northeastern section of this country. Indeed, if it is not eradicated it will finally spread by natural means throughout the range of the eastern white pine from Minnesota eastward and from Canada to northern Georgia and Alabama.

DANGER TO THE WESTERN STATES.

The white-pine blister rust, however, also threatens two of the most important lumber species of the western forests, namely, sugar pine and western white pine. The mature stand of these two is estimated to be worth $240,000,000. Both of these trees have been seriously attacked by this disease in Europe. They are little grown in the Eastern States where this disease is present; hence, we have absolutely no experience to show what the disease may do in this country to them. Aside from the consideration of the total valuation, these two species reproduce readily, and the prospects are good that they will form a very important part of the future forests of their regions. Any reforestation which may be done within their range is likely to consist largely of these two species.

The limber pine, which is distributed throughout the Rocky Mountain region, is known to take this disease in Europe. It, together with the two above-mentioned pines, would furnish a means for the spread of this disease over the entire Pacific coast and Rocky Mountain regions.

There can be no doubt regarding the danger from this disease if it once reaches the Pacific coast or the Rocky Mountain regions, as it has been found by experiment that the wild currants and gooseberries of these sections are susceptible to the disease. Conditions in the natural forests are such that if the native forest once becomes infected there is practically no hope of controlling the disease there; hence, the outlook is especially grave.

The writer has no positive evidence that the white-pine blister rust has ever been west of Indiana. Imported white pines of suspicious origin are known to have been shipped as far west as Illinois and Minnesota, but not beyond the natural range of the eastern white pine.

The western forests are so separated from the eastern forests by the arid Great Plains that the white-pine blister rust can reach the former only through the shipment of diseased nursery stock from the East; consequently, the supreme importance of preventing such shipments. All 5-needle pine stock should be grown from seed in the general locality where the trees are to be planted. Each State west of the Missouri River should immediately enforce an absolute prohibition of the shipment of 5-needle pines or of currants or gooseberries from the section east of the Missouri and Mississippi Rivers. Seed may be shipped with entire safety, so far as this disease is concerned. The importance of such State quarantines can not be too strongly urged.

A destructive disease of white pines known as the white-pine blister rust has been introduced from Europe and seriously threatens our white pines. It also attacks the leaves of wild and cultivated currants and gooseberries and spreads for long distances on them. Look for it on pines in May and early June; on currants and gooseberries from June until the leaves are shed. It appears as shown in the colored figures of Plate I.

Explanation of Plate I.—*A*, A diseased white-pine tree with the blisters broken open, spreading the disease to any currants or gooseberries that may be in the vicinity; *B*, early summer stage on the lower surface of a currant leaf, repeating on currant leaves during the rest of the season, a new crop of spores appearing every two weeks; *C*, early summer stage much magnified; *D*, late summer and fall stage on the lower surface of a currant leaf, spreading the disease back to neighboring white pines.

Figure 4 (on p. 4) indicates the course of the disease from pine to currant (*a* to *b*), from currant to currant (*b* to *c* and *d*), and from currant back to pine (*d* to *a*). The complete circuit from pine back to pine takes one year, but the disease may not develop visibly on the newly attacked pine for a period of several years.

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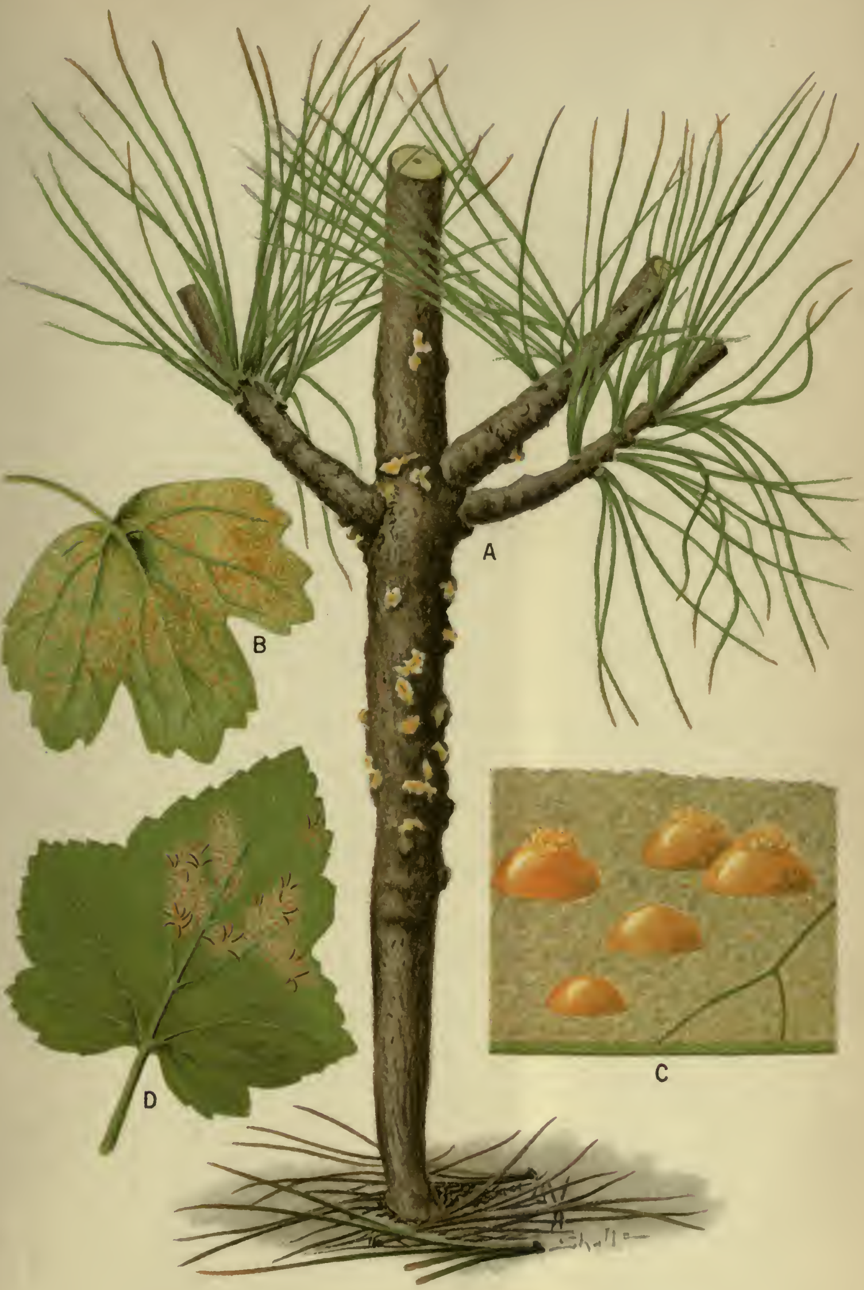

A.Hoen & Co Baltimore

THE WHITE-PINE BLISTER RUST.

Aside from the regions occupied by the four previously mentioned species of white pines, we have the entire remainder of the country in which these species, as well as any other of the white pines, both foreign and American, may be planted as ornamentals. Hence, if the Northeastern States, which do a large proportion of the ornamental nursery-stock trade of the country, become thoroughly infected by this disease, as is sure to happen very shortly if the State authorities are not given complete legal authority for any necessary measures to control it, there is good reason to expect the white-pine blister rust to reach practically all parts of the country where any of the 5-needle pines will grow.

APPEARANCE OF THE DISEASE.

Upon pines the most characteristic symptom is the presence of irregular swellings in the bark. A healthy white pine has a practically uniform diameter throughout the length of each year's growth. A pine affected with this disease is apt to develop a marked swelling at the lower branches if it is a small tree (fig. 5). If a large tree is affected, the smaller branches are apt to show similar more or less irregular swellings. These commonly extend to the bases of smaller side branches and sometimes out into those branches (fig. 5). Sometimes this swelling, instead of showing as a gradually tapering swelling, is very irregular, the bark having a peculiar distended appearance, with rounded swellings located at leaf scars, that is, where a bundle of needles has fallen from the twig (fig. 3). Upon trees only 3 or 4 years of age the disease may cause a shortening of growth and a dwarfing of the top, so that it has an abnormally compact appearance (fig. 1). Upon branches of larger trees this is not usually very evident. Occasionally the leaves upon the affected part of the branch or stem become yellowish, but this is not common. The diseased trunks, branches, or twigs finally die from the girdling effect of the fungus and thus become very noticeable, as they remain upright and do not droop as do twigs affected by frost or by certain insects. Trees up to 25 years of age may have the tops killed in the same way. Do not confuse such dead branches with the work of the white-pine weevil, which is common in many localities. The weevil usually kills only the top central shoot down to the uppermost branches, while the blister rust usually kills side branches or the upper part of the entire top of the tree.

The most certain symptom, however, is that furnished by the fruiting bodies of the parasite, which form upon the thickened bark in the spring from the latter part of April until the middle of June, depending upon the locality and the weather conditions. At first, these thrust themselves from within outward through the swollen bark, in the form of whitish blisters as large as a child's finger nail.

They are usually somewhat longer one way than the other. After a few days the outer membrane, which is white in color, breaks open and the top falls off, exposing the bright-yellow, dusty spores within (Pl. I, *A*). These, after a number of weeks, are completely blown out of the cuplike cavities in the bark. The white membrane surrounding them also disappears, and there remains in the bark merely a rounded hollow, which usually has a whitish, granular appearance within. This is quite characteristic in appearance and, when one becomes familiar with it, is as easily distinguished as are the bright-yellow fruiting bodies themselves. On trees which have been infected when quite young, the disease girdles the main trunk by killing the

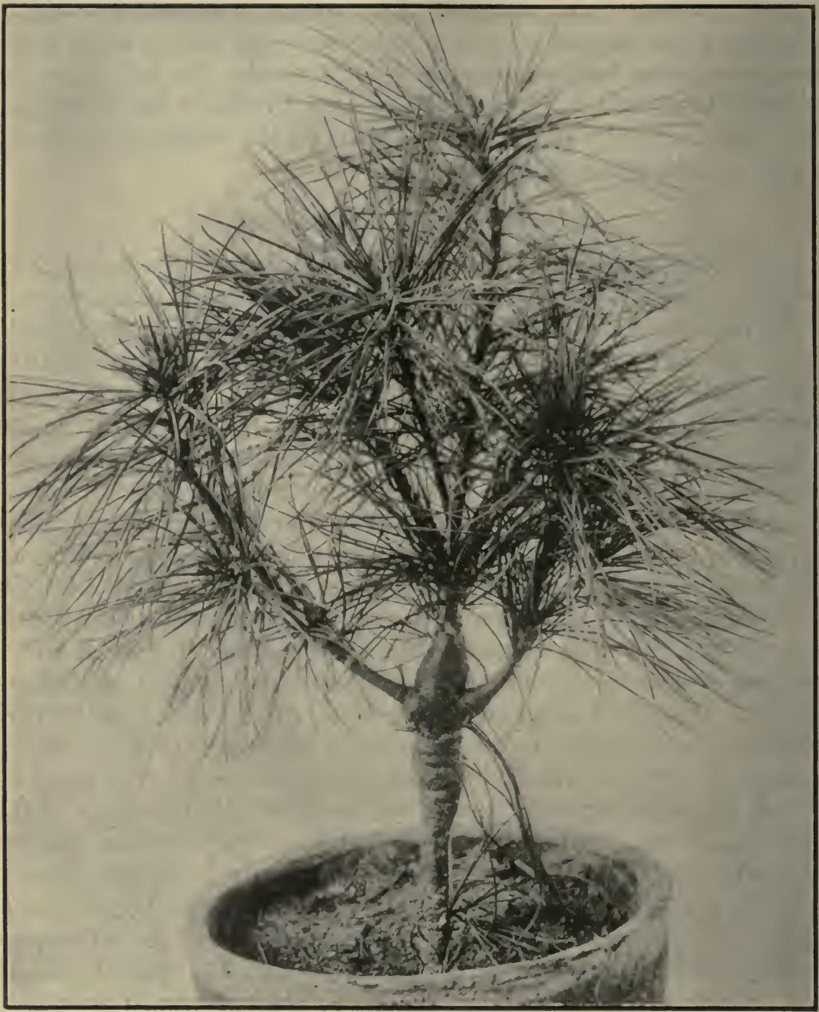

FIG. 5.—White-pine tree 4 years old, showing marked swelling caused by the blister rust. The swelling extends out into the branches. No blisters have yet been produced on this tree. (One-fourth natural size.)

affected bark. In such cases the bark becomes scaly, while on the green parts of the tree it is still smooth (figs. 1 and 2). Oftentimes the tree remains alive several years after being completely girdled with the dead bark. In such cases, growth continues above the canker until considerable swelling is produced. The fruiting bodies form each spring, both above and below the dead area in the bark, additional areas of the bark being killed each year (fig. 1). In this way the disease progresses sometimes 2 or 3 feet from its original point of entry.

On currants and gooseberries the parasite is known to attack only the leaves. Here it has two distinct forms, which may occur upon either the currant or gooseberry, or both. The first or summer form is seen on the lower surface of the leaves in the shape of small, mealy, bright-yellow masses hardly larger than a pinhead, which may be very sparse or may be so abundant as to form a continuous, mealy layer over considerable portions of the leaf surface (Pl. I, *B* and *C*). Upon shaking such a leaf, or blowing it, one will perceive a cloud of yellowish powder set free. This form of the disease may be found from the middle of June until the leaves fall, although it is not so common in the autumn as in July or August.

The second or autumn form of the disease upon currant or gooseberry leaves usually is found from the latter part of July until the leaves fall. It occurs in the form of small groups of 3 to 10 or 12 short, hairy outgrowths, scarcely a quarter of an inch long, ordinarily arranged in small circles (Pl. I, *D*). These, like the summer form, may be very scattering on the under surface of the leaf or may be so abundant as to form a hairy coating on the entire lower surface. These hairs are brownish in color, but in moist weather they assume a grayish brown tint. Both of these forms occur upon the lower surface of the leaf, and usually one must turn a leaf over in order to find out whether it is affected or not. While the disease may kill small areas of the upper leaf surface, so that they look brown or yellowish, this symptom can not be depended upon when one is searching for the trouble.

LIFE HISTORY OF THE PARASITE.

The fungous parasite causing the white-pine blister rust is known by two different technical names. The form upon the pine is known as *Peridermium strobi*, while upon the leaves of currants and gooseberries it is known as *Cronartium ribicola*. The latter name is now ordinarily used for the organism, both upon pines and upon currants and gooseberries. The life history of this parasite is very complex, but it is paralleled by a great number of related fungi.

A period of incubation follows the infection of white pines. This period may vary from less than one year up to six or more years, during which time there is absolutely no external indication of the disease. Then the bark begins to swell at the point of infection (fig. 5). After the swelling of the bark has become apparent upon an infected pine, the healthy green color of the bark on the affected areas is apt to change to a reddish and yellowish color. On the yellowest patches, the parasite pushes forth, through tiny openings in the bark, small drops of a clear, sweet-tasting fluid (fig. 5). This is not pitch. In it, if examined with a microscope, one finds immense numbers of tiny spore bodies. These may be found early in the spring before the formation of the blisters described below, or they may occur apparently at almost any season in late summer and fall. What the function of these tiny spore bodies may be, nobody knows. They occur in a considerable number of closely related parasites, but are not known to reproduce the disease in any way. They are simply indicators of the disease. They are known as pycnospores. Shortly after the pycnospores are produced, from the latter part of April until about the middle of June, the real fruiting bodies push their way through the swollen tissues of the bark until they become visible on the exterior. Here, they first appear like white blisters as large as a child's finger nail. After a brief time, the top of the white membrane breaks loose and falls off. Then it is seen that this membrane surrounds a mass of bright-yellow powder (fig. 1 and Pl. I, *A*). Each grain of this powder is a spore, capable of reproducing the disease. These spores can not, however, infect the pines, but can only attack leaves of currants or gooseberries. After the parasite has fruited once upon the pine, the latter may remain alive until the next year (fig. 1). In most cases, however, the bark is killed completely around the affected part, thus girdling it (figs. 1 and 2). In most cases this means the immediate death of the outer or upper portion of the branch or trunk. Some trees, however, struggle along for a number of years, and sometimes even for 15 or 20 years. In such cases the parasite sends out a new crop of spores each spring to infect any currants or gooseberries that may be in the vicinity. These yellow spores produced in the blisters in the pine bark are known as æciospores, or Peridermium spores.

The Peridermium spores above described are very easily blown about by the wind, and undoubtedly they are distributed mostly in this way. As above indicated, if one of them falls upon a leaf of a currant or gooseberry it is able to attack that leaf (fig. 4, *a* and *b*). There must, however, be present a certain amount of moisture for the spore to germinate. Unless the weather is very dry, the necessary amount of moisture is usually present. In the presence of suitable moisture the tiny spore sprouts somewhat like a grain of corn. It sends its rootlike germ tube into the soft tissues of the currant leaf, and there it spreads within the leaf tissues until it has attained a certain amount of strength and has parasitized a small area of the leaf tissue. Temperature conditions control the rapidity of this development within the currant leaf. If it is abnormally cold, progress is relatively slow. If the temperature is warm the progress is rapid. With a favorable temperature, it requires 12 to 14 days for the parasite in its new home to produce a new crop of spores. These always appear upon the lower surface of the currant leaf in the form of tiny masses, hardly larger than a pinhead, of fine, orange-yellow powder (Pl. I, *B* and *C*). Each of these masses is the result of an infection of the leaf by a single Peridermium spore from the pine. Naturally, the number of these occurring upon a leaf depends entirely upon the number of Peridermium spores which have stuck to that leaf; in fact, they vary from a single one up to many hundreds on a single leaf. In many cases considerable areas of the leaf surface may be completely covered with the powdery, yellow spores, so plentiful has been the infection. These new spores, very curiously, are quite distinct in appearance from those on the pine from which they originated and are called uredospores. Unlike the Peridermium spores of the pine, which can not reinfect the pines, the uredospores of the currant leaf can reinfect currant leaves. This stage is for this reason called a repeating stage. The uredospores first produced from the Peridermium spores in turn are blown about and fall upon the leaves of adjacent currant or gooseberry bushes and there produce still another crop of uredospores. This repetition may go on all the rest of the season, a new generation of uredospores being produced every two weeks (fig. 4, *b* and *c*). This is the time when the disease spreads most rapidly and to the greatest distances. The progress made at this time, of course, depends entirely upon the presence of some currant or gooseberry bush near enough to the one originally infected so that spores will be blown from the one to the other. In many parts of the country currants and gooseberries are cultivated by nearly everybody who has a garden, and in those sections there usually occur from one to six or eight different species of wild currants and gooseberries in the fields, pastures, and forests; so that a census of the currants and gooseberries in a given locality often shows the best of opportunities for the disease in this stage to spread rapidly and for long distances. This stage of the disease is ordinarily found from June 1 until the fall of the leaves.

From the latter part of July until the fall of the leaves still another form of fruiting body and of spores is produced upon the currant and gooseberry leaves. This may appear upon the same spots which have earlier produced the uredospores, but not always (fig, 4, *b*, *c*, and *d*). The new form appears as groups of 3 to 10 or 12 short, stout threads, not over a quarter of an inch in length and usually arranged in small circles (Pl. I, *D*, and fig. 4). Upon these threads are produced spores of another distinct form. These are known as teliospores. These, unlike the uredospores, can not repeat their development upon the currant leaves, but in order to carry on the disease they must attack the bark of young white pines or of young parts of old white pines (fig. 4, *d* and *a*). The teliospores, falling upon bark of suitable age on a white pine, may in turn germinate, penetrate the bark, and grow in the inner layers during the incubation period already mentioned. This infection of the pine bark must take place in the late summer or fall. If the parasite finds conditions very favorable, it may produce the sweetish drops of liquid with the pycnospores early the next spring, and shortly after that it may produce the blisters containing the Peridermium spores. The Peridermium stage is visible on the pines from the latter part of April until the middle of June. This completes the life cycle of the parasite. Because of the fact that the Peridermium spores produced upon pine can not infect pine and that the teliospores produced upon currants can not infect currants, we immediately perceive that if the two sets of host plants are separated widely enough so that the spores produced upon one can not reach the other the disease can not spread.

EFFORTS ALREADY MADE TO CONTROL THE WHITE-PINE BLISTER RUST.

In Europe this disease was firmly established before any eradication of plant diseases was attempted, and the only effort there exerted is merely to keep it in check. There has never been, previously, either in Europe or America, any serious attempt to eradicate a disease of trees of this type; that is, we have had no earlier experience with a disease of this sort by which to guide our attempts at controlling this one. It was in 1909 believed feasible to remove all of the diseased trees from an infected lot of pines during the course of two or three years by repeated annual inspections in the spring when the fruiting bodies of the parasite are most conspicuous on pines. The work then attempted was done with this end in view. It has become increasingly evident since that time that such annual inspections would have to be repeated for an indefinite period, as it has been found that the parasite apparently may lie dormant in an infected tree for six or more years before becoming externally visible. This means that inspection is not efficient. The alternative seems to be that of the total destruction of the entire lot of pines known to be infected. In the work done up to the present time, special emphasis has been given to the removal of all wild and cultivated currants and gooseberries from dangerous proximity to lots of pines known to be infected with the white-pine blister rust.

It has been found, however, in these investigations that the various State officials, who necessarily must perform this work, do not have power to destroy such currants and gooseberries as may seem necessary in order to completely control this disease. The work for this reason has been greatly hampered and in many cases has not been carried out as it should have been. Many people have not realized the seriousness of this trouble, and unanimous action could not be secured. It is absolutely necessary that the State officers have complete power to enforce such measures as are needful for the control of this disease or their work will fail, just as it has failed up to this time.

PRESENT STATUS OF THE WHITE-PINE BLISTER RUST.

During the years 1909 to 1914, inclusive, the white-pine blister rust has been held well in control, considering the circumstances under which the work was carried on. In this period eleven distinct outbreaks of this disease occurred; that is, there were eleven different places where the disease spread from pines to adjacent currants or gooseberries. In these places the disease has been nearly or entirely eradicated. In 1915 the weather conditions were so favorable for the growth of the parasite that it spread very readily on currants and gooseberries for relatively long distances. In 1915 alone twelve distinct new outbreaks occurred. The areas infected vary in extent from only a few currant or gooseberry bushes up to a single area of some 400 or 500 square miles. Unless very energetic action is taken to control the disease at once, it will shortly become impossible to do so.

NEED FOR ADEQUATE STATE LAWS.

As above indicated, there are a number of areas where this disease has spread upon wild and cultivated currants and gooseberries. It is entirely possible to stop its further spread by the mere removal of all wild and cultivated currants and gooseberries within the infected areas. The actual carrying out of this work is not as difficult as is much of the work which is being done in the effort to hinder the spread of other diseases and pests. In carrying on this removal of currants and gooseberries, however, it is absolutely necessary that unanimous action be taken throughout the infected areas. Federal officers have no power to destroy private property in any State. This power is given solely to certain State officers, usually known as State horticultural inspectors. In most cases these State officers do not have power sufficient to compel unanimous action in such removal of currants and gooseberries. This power is one which every State should give to her proper officer at once if this work is to be efficiently done, and if such power is not thus given this serious disease of white pines is certain to escape beyond any possible control and cause irreparable damage.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 743 JULY 24, 1916

Contribution from the Bureau of Animal Industry, A. D. Melvin, Chief.

THE FEEDING OF DAIRY COWS.

By HELMER RABILD, H. P. DAVIS, and W. K. BRAINERD,[1] of the Dairy Division.

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Successful feeding of dairy cows from an economic standpoint involves the providing of an abundant supply of palatable, nutritious feed, at the minimum cost per unit of feed, and supplying it to the cow in such way as to secure the largest production for feed consumed. This bulletin will attempt to give some factors involved in the economical selection of feeds and to guide the producer in supplying them to the cows.

LIBERAL FEEDING NECESSARY FOR PROFIT.

The dairy cow has been likened by many writers to a machine or a manufacturing plant. This comparison can be applied literally, with certain reservations. A certain proportion of the power furnished any machine is used for running the machine itself and is not in any sense productive. In a steam engine this is represented in the exhaust steam, in heat which escapes without producing steam, and in the friction of the working parts of the engine. In the manufacturing plant it is represented by the managerial, the clerical, and sales forces. These forces, while necessary for the successful operation of the business, are, in a sense, unproductive.

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[1] Rewritten and completed by Messrs. Rabild and Davis from incomplete manuscript by Mr. Brainerd, who died in May, 1915.

In the feeding of the dairy cow this overhead expense, this unproductive force, is termed the "maintenance ration," and is that portion of the feed given the cow which is used by her to perform her own functions, such as heating the body, pumping the blood, digesting the feed, and moving the body from place to place. This feed, from a productive standpoint, is entirely lost to the farmer. The cow can produce without loss of body weight only after she has exacted this toll of maintenance. Having received feed enough to maintain her, practically all the feed she consumes above this can be used for milk production. This maintenance ration is a fixed charge, and the more feed a cow can consume above that required for maintenance the greater the amount available for production.

Feeding for profit can, therefore, be defined as liberal feeding, or feeding to the full capacity of the cow. This point is illustrated by Table 1. (These figures are only approximate but will serve to illustrate the point.)

TABLE 1.—*Approximate proportions of cows' feed required for maintenance and available for milk production.*

Cost of ration.	Cost of maintenance.	Available for milk production.	Proportion of ration available for production.
Cents.	*Cents.*	*Cents.*	
10	10	....	....
15	10	5	One-third.
20	10	10	One-half.
25	10	15	Three-fifths.

It will be noted in Table 1 that when the cow is fed only a maintenance ration no feed is available for milk production; when she is fed twice this quantity, half the feed can be used for milk production; when she is fed two and a half times the maintenance, three-fifths of the feed can be so used. One of the most common mistakes in the feeding of dairy cattle on our farms is that the good cows are not fed a sufficient quantity of feed above that required for maintenance. This is especially true of the highly specialized dairy cow; that is, the cow which when fed all she will take makes it all into milk, except what is needed for maintenance. It is, however, unfortunately true that all cows in the dairies of the country are not this kind. Some cows when fresh make all the feed above maintenance into milk for a period of several months before they begin to lay on flesh; others, if fed heavily, begin to gain in weight soon after freshening. From the standpoint of economical milk production one can not generally afford to give a dairy cow more than she will consume without gaining in weight. There are times, however, when it is desirable to make exceptions to this rule; for example, practically all highly specialized milk producers in the early part of the lactation period lose in weight; that is, they produce milk at the expense of their own body flesh. When such cows approach the end of their milking period they normally regain the flesh they have lost in the early part of this period. The feeder can, therefore, well afford to feed such cows liberally, being assured that the feed will be returned to him in the form of milk when the cows again freshen.

SUMMER FEEDING.

The problems involved in winter and summer feeding are so different as to make a natural division between the two. Summer feeding ordinarily consists in the use of pastures or soiling crops. These may be supplemented when necessary by silage or other roughage or by grain. When dry feeds alone are fed in the summer, the problems are not materially different from winter feeding.

PASTURE.

Pasture is the natural feed for dairy cows, and in many respects the best. With abundance of good grasses in fresh, succulent condition, we have one of the rations most conducive to heavy production. Even with the very best of pasture, however, a cow can not be forced to maximum production on it alone. This is owing to the fact that for the greatest production she must be induced to take a large amount of nutrients. The bulky nature of pasture grass places a positive limit upon the capacity of the cow to take feed. In other words, the cow's stomach can not contain grass enough to supply the required nutrients for maximum milk production; therefore, a part of the ration should be of a more concentrated nature. Good pasture contains an abundant supply of succulent, palatable, and nutritious grasses. On such pasture it should be possible for a cow to satisfy her appetite with a few hours' grazing. Pasture of this kind will supply all the food material needed for medium production and a large part of that necessary for large production. For average conditions, with ample pasture of good grasses or legumes in good, succulent condition, good production can be secured. The economy of the use of pasture depends chiefly upon several factors, such as the price of land, the price of labor, and the lay of the land.

PRICE OF LAND.

The price of land has a direct bearing upon the cost of pasture and is an important factor where land values are high. If pasture is to be depended upon entirely for from four to six months in the year, and production is to be kept up to a profitable standard, anywhere from 1 to 4 acres or more must be provided for each cow. This is assuming that in permanent pasture there is a good, clean turf, with little or no waste places, and that for temporary pasture there is a good stand of grass or legumes throughout. Land which will give these conditions frequently sells at from $50 to $300 an acre, and the interest on the investment must necessarily also vary widely, as is shown in Tables 2 and 3:

TABLE 2.—*Interest on cost of pasture per cow for the season; interest at 6 per cent on the value of the land, allowing from 1 to 4 acres per cow.*

Acres per cow.	Value of land per acre.				
	$25	$50	$100	$150	$200
1	$1.50	$3.00	$6.00	$9.00	$12.00
1½	2.25	4.50	9.00	13.50	18.00
2	3.00	6.00	12.00	18.00	24.00
2½	3.75	7.50	15.00	22.50	30.00
3	4.50	9.00	18.00	27.00	36.00
3½	5.25	10.50	21.00	31.50	42.00
4	6.00	12.00	24.00	36.00	48.00

TABLE 3.—*Cost of pasture per cow per day on basis of Table 2, with a pasture season of 150 days.*

Acres. per cow.	Value of land per acre.				
	$25	$50	$100	$150	$200
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1	1	2	4	6	8
1½	1½	3	6	9	12
2	2	4	8	12	16
2½	2½	5	10	15	20
3	3	6	12	18	24
3½	3½	7	14	21	28
4	4	8	16	24	32

It will be seen that the price of land may readily become so high that it would be unprofitable to graze it. In many sections of the country a cow can be fed on dry feed for average production for about 20 cents a day. Therefore, when the daily rental or interest on the value of pasture approaches that sum the farmer should carefully consider other methods of summer feeding.

The cost of caring for permanent pastures must also be taken into consideration. This will consist in the expense of cutting weeds, building and repairing fences, etc.

PRICE OF LABOR.

The pasture system of summer feeding reduces to the minimum the amount of labor required to handle a given number of cows, and, therefore, it is especially adapted to conditions where labor is high.

LAY OF LAND AND ROUGHNESS OF SURFACE.

In mountainous or hilly sections of the country there is often a part of the farm which, on account of steepness, tendency to wash, or the presence of rock formation near the surface, can not or should not be plowed frequently. On such farms it is often best to plow only the bottoms, keeping the uplands in permanent pastures. The dairyman will find ready application of the pasture system for summer feeding on such farms.

PASTURE WITH SUPPLEMENTS.

GRAIN.

As has been said, the supplementing of pastures with grain is sometimes advisable, even when the pastures are of the best. In many sections, however, pastures are never of the best kind, and in no sections are they always in the best condition. It is evident, therefore, that the commercial dairyman will seldom depend upon pasture alone. Grain should be fed to heavy-producing cows under all pasture conditions.

Prof. C. H. Eckles, of the University of Missouri, suggests the following-named quantities of grain with abundant pasture for varying production:

Jersey cow producing—	
20 pounds of milk daily	3 pounds of grain.
25 pounds of milk daily	4 pounds of grain.
30 pounds of milk daily	6 pounds of grain.
35 pounds of milk daily	8 pounds of grain.
40 pounds of milk daily	10 pounds of grain.
Holstein-Friesian or Ayrshire cow producing—	
25 pounds of milk daily	3 pounds of grain.
30 pounds of milk daily	5 pounds of grain.
35 pounds of milk daily	7 pounds of grain.
40 pounds of milk daily	9 pounds of grain.
50 pounds of milk daily	10 pounds of grain.

While this is, of course, an arbitrary rule and variations should be made to suit different conditions and individual cows, it is in accord with good feeding practice and probably is as good a rule of its kind as has been formulated.

For cows of medium production it is usually more economical to feed silage or some green crop rather than grain for supplementing short pasturage. In supplementing pasture with grain it should be remembered that the percentage of protein in the grain ration need not be the same as for winter feeding. Good pasture is an approximately balanced ration. The grain ration to be fed with pasture grass should, therefore, have approximately the same proportion of protein to other nutrients. In the case of extra-heavy producers the percentage of protein in the grain mixture should be somewhat greater.

The following-named mixtures are suggested for supplementing pasture without other roughage:

Mixture No. 1:

Ground oats	100 pounds	Per cent digestible protein, 10.3.
Wheat bran	100 pounds	
Corn meal	50 pounds	

Mixture No. 2:

Wheat bran	100 pounds	Per cent digestible protein, 12.7.
Corn meal	100 pounds	
Cottonseed meal	25 pounds	

Mixture No. 3:

Corn-and-cob meal	250 pounds	Per cent digestible protein, 15.5.
Cottonseed meal	100 pounds	

Mixture No. 4:

Wheat bran	100 pounds	Per cent digestible protein, 13.6.
Gluten feed	50 pounds	
Corn meal	50 pounds	

SOILING CROPS.

Pastures, except where irrigation is practiced, are so dependent upon rainfall that there is practically sure to be some period each season when they are short. It is a well-known fact among dairymen that if a cow, for lack of proper feed, falls off in her flow of milk for any period of time it is difficult or impossible to bring her back to a full flow until she again freshens. To carry the cows over this period on grain alone is expensive; consequently, the supplementing of pasture with soiling crops is becoming much more common and is growing in favor. In fact, in many sections it is extremely difficult to keep a herd in maximum production throughout the summer without furnishing some supplemental feed. Unless an abundance of pasture is available, there is practically sure to be a shortage toward the end of the season. Special crops can be grown for these shortages, but they usually involve added expense and inconvenience compared with standard farm crops. Second-growth red clover, oats, peas, or alfalfa are excellent. Corn is available in August and September. These crops are usually a part of the regular cropping system of a well-conducted dairy farm.

The advantages of soiling crops as a supplement to pasture are that large quantities of forage can be grown on a relatively small area, because it is frequently possible to harvest more than one crop in a season on land used for soiling. Another advantage is the palatability and succulence possessed by such crops. With their use pasture need not be cropped so closely and less feed is wasted through tramping by the cattle. By judicious application of the soiling system it is often possible to reduce the acreage of land used for pasture, which in addition to the saving in land required for pasture has the added saving in the cost of fencing. Soiling crops usually are fed in the stable where the manure can be saved for application on cultivated fields.

An objection which can be urged against the use of soiling crops is the greater amount of labor required and the difficulty in using this labor to the best advantage. Another difficulty is to plan a succession of special crops which will at all times during the season supply an abundant supplementary feed. Even with the best arranged plan, its success depends very largely upon weather conditions.

THE SUMMER SILO.[1]

Silage has found a wide use in this country as a palatable, succulent, and economical roughage for use during the winter. Many of the advantages of its use in winter apply equally well in summer, and there are additional ones that apply alone to the latter season.

The use of a summer silo is particularly applicable on high-priced land. If the land is pastured it will require from 1 to 3 or more acres a season for each cow, while 1 acre of corn put in the silo will supply succulent roughage for several cows for a like period. It is true that grain will be necessary in addition to silage, but the great problem on high-priced land is to raise a sufficient quantity of roughage.

As has previously been said, soiling crops have been used to a great extent either in place of or in addition to pasture. The greatest disadvantage in their use is that much labor is required. In order to use these crops they must be cut and hauled from day to day. This work is expensive because only small areas are cut at one time, thus making it impracticable to use the harvesting machinery of the farm to advantage and entailing considerable loss of time in harnessing and unhitching the team. Considerable inconvenience also is occasioned by the fact that the field work is pressing at that season of the year and both man and horsepower are badly needed in the fields. Silage, on the other hand, is cut at one operation when the work in the field is not pressing. The crop ordinarily grown for silage is corn, which is a part of the regular farm rotation and consequently fits in well with the regular routine of work.

With a silo for summer feeding, the dairyman always has an abundant supply of feed that is easily handled. By using silage the necessity of cutting and hauling the supplementary roughage during rainy weather is eliminated. Another advantage as compared with the soiling system lies in the fact that with the latter it is often necessary to feed a portion of each crop after it has matured too much to be palatable, and probably to start on the succeeding one while it is still a little too green. It is difficult to plan exactly so as to prevent these conditions. With silage, however, the crop can be cut at the best stage for feeding and preserved at that point.

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[1] See Farmers' Bulletin No. 578, "The Making and Feeding of Silage."

One of the most important uses of silage in the summer is as a supplement for short or poor pasture. This condition frequently occurs as a result of long-continued dry weather. Under such circumstances even the most carefully planned soiling system may fail. It is then that the greatest value of the summer silo is realized, for with the silo full of well-matured silage grown in the previous season, an abundant supply of succulent feed for the cows is available, regardless of weather conditions.

When it is not necessary to use the silo during the summer, it can be sealed up and the silage preserved for winter use. This prevents any waste in feed.

One point, however, must be kept in mind in planning the summer silo.[1] This is the diameter of the silo in relation to the number of cows to be fed and the quantity to be fed to each cow. Silage enough must be fed daily to prevent excessive surface fermentation. As a general rule, a cow under summer conditions will consume about 20 pounds a day. On this basis the diameter of the silo in reference to the number of cows to be fed in summer will be as follows:

20 cows	8 feet in diameter.
30 cows	10 feet in diameter.
40 cows	12 feet in diameter.

Inasmuch as 8 feet is about the minimum diameter of a silo in best practice, it will be seen that the summer silo for supplementing pasture has its best application in herds of 20 cows or more.

WINTER FEEDING.

The problems involved in winter feeding are usually distinctly different from those of summer feeding. Pasture (or green feed), usually the basis of summer feeding, is not available. Broadly speaking, there are two factors involved in this problem, first, to satisfy the needs of the cow and, second, to suit the pocketbook. The cow must have an ample supply of feed of a palatable nature, and this feed must be supplied at a price which will permit a profit on the feeding operation.

Viewed from an economic standpoint, there are some fundamental considerations which should first receive attention. In general farm practice it is advisable, so far as is economical, to use the feeds produced on the farm. Often the freight rates and the middleman's charges, if saved, will constitute a good profit for the feeder. This is especially true of roughage. Such feeds are bulky and in most cases must be baled at a considerable cost; the freight rates also are much greater in proportion to the nutrients contained than on the grains.

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[1] See Farmers' Bulletin No. 589, "Homemade Silos."

When land is high in price and the markets for dairy products are good, it is often impracticable to grow all the feeds on the farm. In such cases arrangements first should be made to grow the roughage, on account of the high cost of transporting these feeds. In most cases the prime object of the farm under such conditions will be to supply the greatest possible quantity of roughage.

It is a difficult problem to provide a system of winter feeding of roughage which will make the best use of home-grown roughage and at the same time insure full production. Only a general discussion of the problem can be attempted.

SILAGE.

In addition to containing the proper nutrients in the right proportion, part of the ration should be of a succulent nature. It is extremely difficult, if not impossible, to keep cows in full production throughout the winter without some succulent feed. There are two chief sources of succulent feed for winter feeding—silage and roots. Of these, silage is in almost universal use by commercial dairymen. While almost any green crop may be used for silage, the heavy yields of corn, as compared with other crops, and its comparative ease of handling, together with its keeping qualities, make it the leading silage crop. Where the cost of land and the prices of dairy products are high, and the system of farming of necessity is intensive, it is questionable whether the dairyman should consider any other silage crop.

ROOTS.

The chief function of roots in cattle feeding is to supply a succulent feed. Under general farm conditions the quantity of nutrients grown per acre in root crops is small in comparison to the cost of production. These root crops, however, can be preserved during the winter equally well whether large or small quantities are fed each day, and therefore have special application when only a few cows are to be fed. Of the different root crops, mangel-wurzels furnish the greatest yield per acre. Other kinds of beets and turnips and carrots may be used. Turnips, however, should be fed after milking rather than before, as they cause a bad flavor in the products if fed immediately before milking. Carrots impart a desirable color to the milk.

DRY ROUGHAGE.

The best kinds of dry roughage to be fed to the dairy cow, in connection with corn silage or roots, are leguminous hays, such as alfalfa, red, crimson, or alsike clover and soy-bean or cowpea hay. While corn silage is an excellent feed, it is not a balanced one, as it does not contain sufficient protein and mineral matter to meet fully the requirements of the cow. The leguminous hays, in addition to being very palatable, have a tendency to correct this deficiency. They are also one of the best and cheapest sources of protein. One or more of these hays can be grown on any farm, and in addition to their value for feeding purposes, they improve the soil in which they are grown. Hay from Canada field peas, sown with oats to prevent the peas from lodging, also makes an excellent roughage.

Corn stover, coarse hay, etc., also find a good market through the dairy cow. This class of roughage is low in protein, however, and when it is used the grain ration must be richer in protein.

No positive rule can be laid down as to the quantity of dry roughage that should be fed, but about 6 to 12 pounds a day for each cow, in addition to silage, will be found to be satisfactory in most cases. When the dry roughage is of poor quality, such as coarse, weedy hay or a poor grade of cornstalks, a large portion can often be given to advantage, allowing the cow to pick out the best and using the rejected part for bedding. With this quantity of dry roughage the cow will take, according to her size, from 25 to 50 pounds of silage. This may be considered as a guide for feeding to apply when the roughage is grown on the farm. When everything has to be purchased, it is often more economical to limit the quantity of roughage fed and increase the grain ration.

ROUGHAGE ALONE TOO BULKY A RATION.

While a cow's stomach is large and her whole digestive system is especially designed to utilize coarse feeds, there is a limit to the bulk that she can take. This limit is below the quantity of roughage that it would require to furnish the nutrients she must have for maximum production; that is, a ration may contain the proper proportions of protein and carbohydrates and still be so bulky that she can not handle it. She therefore should have some grain even though the roughage in itself is a balanced ration.

IMPORTANCE OF A BALANCED RATION.

It is probably well at this point to refer briefly to the composition of feedstuffs as it relates to economical feeding of the dairy cow. The cow takes into her digestive system feeds which she utilizes for the production of body tissues, heating the body, performing bodily functions, such as digesting feed, moving from place to place, and for milk production. For the purposes of the present discussion, it is sufficient to say that the constituents or compounds and the relative quantities necessary for these operations have been determined; that is, we know that milk contains protein and energy or heat-producing constituents, the protein being represented by the casein and albumin and the energy and heat-producing constituents by the fat and sugar. In addition to the constituents or compounds necessary for the production of milk, she also must have the constituents necessary for performing the other functions mentioned. These, for convenience, have been classified into proteins, carbohydrates, and fats. Fats perform much the same functions as carbohydrates and are worth for production practically two and one-fourth times as much per pound as carbohydrates, and in the balancing of a ration are usually classed with them. This brings us to a definition of a "balanced ration," which is a ration containing these various nutrients in the proportion the cow needs them.

The economical importance of a balanced ration is evident. The cow can use only certain elements or compounds in certain proportions; consequently, if the ration supplies an excessive amount of any one, the excess is liable to be wasted. Not only is this true, but as the cow has to assimilate it even though she can not use it, her capacity for production is reduced.

COST.

In making a ration, cost is one of the important factors. The best practice is to compound a grain mixture so that it will balance with the home-grown roughage. With this in mind, the separate grains should be selected to supply the necessary nutrients at the lowest possible cost. For this, not only the price per hundred pounds but also the relative cost of each constituent, especially protein, must be considered. For example, to determine the cost of a pound of digestible protein in a given feed divide the price of 100 pounds by the per cent of digestible protein in the feed. If this calculation is made for several feeds, the relative cost of protein in each will be apparent. Then the feeds that furnish protein at the least cost can be selected. The same can be done to determine the cost of the carbohydrates and fat, which are the heat-making or energy-producing part of the feed.

BULK.

A certain bulk is necessary in the grain mixture to obtain the best results. When heavy feeds are used, some bulky ones should be included to lighten the mixture, since it is probable that a certain degree of bulkiness aids digestion. Some of the common feeds are classified as to bulk in Table 4:

TABLE 4.—*Classification of common feeds as to bulkiness.*

Bulky.	Medium.	Heavy or compact.
Alfalfa meal.	Corn meal or feed.	Cottonseed meal.
Corn-and-cob meal.	Hominy.	Linseed meal.
Bran (wheat).	Gluten feed.	Coconut meal.
Dried brewers' grains.	Rye.	Peanut meal.
Dried distillers' grains.	Barley.	Gluten meal.
Oats, ground.	Buckwheat middlings.	Wheat middlings.
Malt sprouts.		
Dried beet pulp.		

PALATABILITY.

Palatability is of great importance in successful feeding. The best results can not be obtained with any feed which is not well relished by the cow; consequently any unpalatable feed to be used should be mixed with those that are appetizing.

PHYSIOLOGICAL EFFECT.

In making the grain mixture care should be exercised that too large a quantity of either constipating or laxative feed is not included. Cottonseed meal, for example, is decidedly constipating and should be fed with laxative grains or succulence, such as silage or roots. For ordinary feeding in most parts of the United States not more than one-third of the grain should be cottonseed meal. In some sections larger quantities have been fed, but this practice is not to be recommended. On the other hand, linseed-oil meal, because of its distinctly laxative action, should not be fed ordinarily in greater quantities than 1½ pounds a day.

NUTRITIVE VALUE OF THE GRAINS AND CONCENTRATES.

As a general rule, the energy or heat-producing material is found chiefly in the stem and leaves of the plant and the protein is largely in the seeds. The great exception is in the case of legumes, which have larger percentages of protein throughout the plant and particularly in the leaves. It should be noted, therefore, that in supplying grain we are chiefly concerned with the protein it contains.

Two classes of feeds are used for making up the grain ration, namely, grains and by-products of the manufacturing industries. The grains produced on the farm and commonly used for cattle feeding are corn, oats, barley, and rye. In many cases the demand for these grains for other purposes has become so great that the dairyman can not afford to use them; consequently, it has usually been found more economical to use the by-products of the manufacturing industries. The following are among the most common of these feeds: Wheat bran, wheat middlings, linseed meal, cottonseed meal, gluten meal, gluten feed, hominy feed, brewers' grains, malt sprouts, distillers' grains, beet pulp, molasses, buckwheat middlings, coconut meal, peanut meal.

The following analyses[1] represent digestible nutrients in 100 pounds. The fat is multiplied by 2.25 and added to the carbohydrates. This represents the energy or heat-making part of the feed.

WHEAT BRAN.

Digestible nutrients.—Protein, 12.5 per cent; carbohydrates and fat, 48.4 per cent.

Bran is the outside coating of grains, and is the residue or by-product from the manufacture of flour. Wheat bran may be derived from winter or spring wheat, and there is little difference in its composition from either source.

From a physiological standpoint wheat bran is one of the very best feeds for cows. It is slightly laxative in nature, and generally tends to keep the cow's digestive system in good condition. The price based upon its protein content is usually so high that most commercial dairymen combine it with other feeds in which protein costs less per pound. Aside from the value of the nutrients which it contains, it has a special value in a feeding mixture, as it gives bulk and adds to the palatability. Wheat bran may be used when the rest of the grain ration is lacking in palatability or is of a constipating nature. It is especially good when the roughage is all dry. The best grades of wheat bran are of light weight, with large flakes. Some of the large mills put the sweepings from the mill into the bran; therefore, it is usually best to buy the highest grade of bran, provided the mills grading it are reliable. The output of small country mills is usually of excellent quality. Bran contains a high proportion of phosphorus and potash in its ash content.

WHEAT MIDDLINGS.

Digestible nutrients.—Protein, 13.4 per cent; carbohydrates and fat, 55.9 per cent.

Standard wheat middlings or shorts are composed of the finer portions of the bran together with the coarser portion of the flour. They are not quite so flaky as bran, are a little less laxative, and contain a somewhat smaller quantity of ash. In other respects they may be said to resemble bran closely. This feed is somewhat pasty when moist, and consequently lacks bulk.

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[1] The analyses of digestible protein, carbohydrates, and fat of the various feeds are taken from "Feeds and Feeding," by Henry and Morrison.

LINSEED MEAL.

Digestible nutrients.—Old process: Protein, 30.2 per cent; carbohydrates and fat, 47.7 per cent. New process: Protein, 31.7 per cent; carbohydrates and fat, 44.2 per cent.

Linseed meal is a by-product of the manufacture of linseed oil from flaxseed, and is produced under two processes, known as the old and the new. Linseed meal or oil meal from a physiological standpoint is one of the very best feeds. It is laxative, palatable, and a very good "conditioner," but, like wheat bran, its price is usually excessive for its nutritive value. It has, however, a distinct place in a mixture in supplying protein to increase the palatability and improve the physiological effect. It is very heavy, so that it is well to feed it in connection with a bulky feed. It is especially applicable in a mixture to be fed with dry roughage.

COTTONSEED MEAL (CHOICE).

Digestible nutrients.—Protein, 37 per cent; carbohydrates and fat, 41.2 per cent.

Cottonseed meal is the richest in protein of all the common cow feeds on the market. It is usually the cheapest source of protein available, but it does not have the best physiological effect upon the cow, often causing digestive troubles if fed in large quantities for long periods. At first it is advisable to start with 1 to 2 pounds a day, gradually increasing the quantity if no bad results are observed. In some herds in the North as high as 5 to 6 pounds a day are fed without bad results. In the South there seems to be no limit in this direction.

Cottonseed meal is a highly concentrated feed and should, if possible, be fed in a mixture with some bulky feed like bran. It can be fed to better advantage when the roughage contains an ample quantity of succulent feed. While its physiological effect in the North at least is not good as compared with most other cow feeds, its cheapness and the fact that in time the cows seem to overcome this tendency to digestive trouble from it are rapidly giving it great prominence as a cheap source of protein for dairy cows.

GLUTEN MEAL AND GLUTEN FEED.

Digestible nutrients.—Gluten meal: Protein, 30.2 per cent; carbohydrates and fat, 53.8 per cent. Gluten feed: Protein, 21.6 per cent; carbohydrates and fat, 59.1 per cent.

Gluten meal is a by-product of the manufacture of starch from corn. The basis of the meal is the germ part of the corn kernel. Gluten feed is composed of the gluten meal plus a certain quantity of corn bran, which makes it lighter than the meal. Both feeds are fairly palatable and are usually among the cheapest sources of protein.

DRIED BREWERS' GRAINS.

Digestible nutrients.—Protein, 21.5 per cent; carbohydrates and fat, 44.2 per cent.

Dried brewers' grains rank with wheat bran as a flaky, bulky feed. The physiological effect is nearly if not quite as good as bran. They differ in that they carry a somewhat larger percentage of protein than bran. Cows sometimes do not eat these grains readily at first, but soon overcome this aversion.

MALT SPROUTS.

Digestible nutrients.—Protein, 20.3 per cent; carbohydrates and fat, 50.3 per cent.

Malt sprouts are loose and bulky and cows usually do not take them readily at first. The chief place of this feed is with other feeds in a mixture. Both brewers' grains and malt sprouts come from barley and are by-products from the manufacture of beer.

The proprietary feed companies control at the present time a large percentage of the output of dried grains and malt sprouts from the larger breweries and these excellent feeds do not now appear unmixed on the market to so great an extent as they did a few years ago.

HOMINY MEAL, FEED, OR CHOP.

Digestible nutrients.—Protein, 7 per cent; carbohydrates and fat, 77.6 per cent.

This by-product of the manufacture of hominy consists of part of the starchy portion of the corn and part of the germ. It is variously known, as the heading suggests, as hominy meal, feed, or chop. In many respects it resembles corn and is a good substitute for it. This feed is used chiefly to furnish the energy or heat-making part of the ration, but because of its low percentage of protein it is not an economical source of the latter.

DRIED DISTILLERS' GRAINS.

Digestible nutrients.—Corn grains: Protein, 22.4 per cent; carbohydrates and fat, 66.5 per cent. Rye grains: Protein, 13.6 per cent; carbohydrates and fat, 52.8 per cent.

These grains are the by-product of the manufacture of alcohol and distilled liquors from corn and rye. Both kinds are rather bulky and usually the corn grains are among the cheapest sources of protein. These grains are not particularly palatable, consequently they should be used with other feeds in the grain ration.

DRIED BEET PULP.

Digestible nutrients.—Protein, 4.6 per cent; carbohydrates and fat, 67 per cent.

Dried beet pulp is a by-product from the manufacture of sugar from the beet. As a source of protein it is not of high value, and the farmer should recognize this fact when he buys it. It is bulky, however, and has an excellent physiological effect upon the cow, as it aids in keeping her digestive organs in good condition. When for any reason neither silage nor roots are available the pulp can be soaked for about 12 hours in about four times its weight of water; it then constitutes a good substitute for a succulent roughage. Beet pulp should be classed as a carbohydrate rather than as a protein feed.

MOLASSES.

Digestible nutrients.—Protein, 1 per cent; carbohydrates and fat, 58.2 per cent.

Molasses, from both the beet and cane sugar factories, is valuable as a source of energy or heat-making material, the main difference between the two kinds being that the former is more laxative when fed in large quantities. When fed in small quantities, molasses adds materially to the palatability of the ration, but unless it is very low in price it is not usually an economical feed for dairy cows.

BUCKWHEAT MIDDLINGS.

Digestible nutrients.—Protein, 24.6 per cent; carbohydrates and fat, 52 per cent.

This floury feed is composed largely of that part of the buckwheat kernel under the hull together with some of the coarsest of the flour. It is rather heavy and tends to produce a tallowy butter if fed in large quantities. In certain sections it is one of the cheap sources of protein. Frequently bran and chaff are added to the middlings, thus greatly reducing their feeding value.

COCONUT MEAL.

Digestible nutrients.—Protein, 18.8 per cent; carbohydrates and fat, 60.2 per cent.

This meal is the ground cake resulting from the manufacture of coconut oil. It is a rather heavy feed which, on account of its high oil content, tends to become rancid if kept for long periods in the summer. If it is possible to obtain coconut meal at a reasonable price it will be found to be a valuable addition to the ration.

PEANUT MEAL.

Digestible nutrients.—Hulled nuts: Protein, 42.8 per cent; carbohydrates and fat, 36.6 per cent. With hulls: Protein, 20.2 per cent; carbohydrates and fat, 38.5 per cent.

This meal is the by-product of the manufacture of peanut oil and varies greatly in composition, depending upon the percentage of hulls it contains. It is an excellent dairy feed and in some sections is a cheap source of protein.

FARM GRAINS.

Some of the more common grains that are grown upon the farm will be described briefly below.

CORN.

Disgestible nutrients.—Corn meal: Protein, 6.9 per cent; carbohydrates and fat, 76.9 per cent. Corn-and-cob meal: Protein, 6.1 per cent; carbohydrates and fat, 72 per cent.

Corn is probably the most common grain grown upon the farm and is well adapted to be part of the ration of a dairy cow. Corn is palatable, heavy, and one of the best and cheapest sources of the energy or heat-making part of the ration, but, on account of its low protein content, it should not form the entire grain ration. In order to lighten up this grain, the cob is often ground with the kernel, the resulting meal being called corn-and-cob meal. This feed is more bulky and better adapted for mixing with heavy grains.

OATS (GROUND).

Digestible nutrients.—Protein, 9.4 per cent; carbohydrates and fat, 60.6 per cent.

This very palatable cereal is slightly laxative and very well adapted for feeding dairy cattle. Owing to the high market price of oats, it is usually more economical to sell them and purchase other feeds which furnish nutrients at a cheaper price.

BARLEY (GROUND).

Digestible nutrients.—Protein, 9 per cent; carbohydrates and fat, 70.4 per cent.

This is a palatable feed and one that can be used to good advantage as a source of carbohydrates or energy material for dairy cows where its price is moderate. Like corn, it should not be the only grain in the ration.

RYE (GROUND).

Digestible nutrients.—Protein, 9.2 per cent; carbohydrates and fat, 70.5 per cent.

This grain is not especially palatable and should not be used in large quantities, as it tends to produce a hard, tallowy butter. Mixed with other feeds, it is often a valuable addition to the ration.

ROUGHAGE.

All roughage may be divided for convenience into two general classes with reference to its content of protein. In the first, or low-protein, class are placed corn silage, corn stover, timothy hay, millet hay, prairie hay, hays from the common grasses, straws of the various cereals, and cottonseed hulls. The second, or high-protein, class includes the various legume hays, such as alfalfa, the clovers, cowpea, soy bean, and oat and pea. Economy in feeding demands that grain should supplement the roughage, consequently the grain mixtures will be compounded to fit the class to which the roughage belongs.

COMPOUNDING A GRAIN MIXTURE.

A few simple rules for making-up a grain mixture are given briefly below:

1. Make up the mixture to fit the roughage available. With roughage entirely of the low-protein class the grain should contain approximately from 18 to 22 per cent of protein, while with exclusively high-protein roughage the grain ration need contain only about 13 to 16 per cent.
2. Select grains that will furnish the various constituents, especially protein, at the least cost, using home-grown grains if possible.
3. Be sure that the mixture is light and bulky.
4. The mixture should be palatable.
5. See that the grain has the proper physiological effect upon the cow.

All these suggestions should be kept in mind in order to obtain the best possible combination of grains. For the convenience of the feeder Table 5, showing the digestible protein content of the more common grains and by-products feeds, is given. The per cent columns are arranged in 5 per cent divisions.

TABLE 5.—*Approximate digestible protein content of various grains and by-products.*

Average 5 per cent (2.5 to 7.4 per cent).	Average 10 per cent (7.5 to 12.4 per cent).	Average 15 per cent (12.5 to 17.4 per cent).	Average 20 per cent (17.5 to 22.4 per cent).
Corn meal. Corn-and-cob meal. Hominy feed. Dried beet pulp.	Wheat, ground. Oats, ground. Barley, ground. Rye, ground. Buckwheat, ground. Sorghum grains, ground.	Wheat bran. Wheat middlings. Dried distillers' grains (rye).	Gluten feed. Malt sprouts. Dried brewers' grains. Dried distillers' grains (corn). Coconut meal. Peanut meal with hulls. Cowpeas.
Average 25 per cent (22.5 to 27.4 per cent).	Average 30 per cent (27.5 to 32.4 per cent).	Average 35 per cent (32.5 to 37.4 per cent).	Average 40 per cent (37.5 to 42.4 per cent).
Buckwheat middlings.	Gluten meal. Linseed meal (both processes). Soy beans.	Cottonseed meal.	Peanut meal (hulled nuts).

The per cent of protein in a grain mixture may be found as follows: Take any number of parts of any number of feeds in the table, and for each part put down the per cent of the column in which it is found. Add these numbers and divide the sum by the number of parts. Examples:

1 part wheat bran		15
1 part cottonseed meal		35
1 part gluten feed		20
3	3)	70
		23. 3 per cent protein.

3 parts wheat bran (3×15)		45
2 parts cottonseed meal (2×35)		70
1 part gluten feed (1×20)		20
6	6)	135
		22. 5 per cent protein.

The approximate price of a ration per pound of protein may be ascertained as follows: Divide the total price of the mixture by the average protein content as derived above. The mixture costing the smallest price per pound of protein, other things being equal, is the most economical. Unfortunately, other things are never exactly equal, for the physiological effect of the grain, bulk, and palatability must also be taken into consideration. Practically all the grain feeds low in protein are rich in carbohydrates, but, as already stated, grains are purchased primarily for their protein content, as almost invariably the carbohydrates can be produced more cheaply in the form of corn silage, cornstalks, etc. While the above-mentioned method of testing the economy of a grain ration is not entirely accurate, it is usually a safe method to follow.

SAMPLES OF GRAIN MIXTURES TO BE FED WITH VARIOUS ROUGHAGES.

WITH LOW-PROTEIN ROUGHAGES.

The following grain mixtures are adapted to be fed with roughages of the low-protein class, such as corn silage, corn stover, timothy, prairie, rowen, or millet hays, cottonseed hulls, etc.:

Mixture 1.—Per cent of digestible protein, 18.4:
500 pounds corn meal.
400 pounds dried distillers' grains (corn).
200 pounds gluten feed.
300 pounds linseed meal (old process).

Mixture 2.—Per cent of digestible protein, 19.8:
100 pounds corn meal.
100 pounds cottonseed meal.
100 pounds linseed meal (old process).
200 pounds wheat bran.

Mixture 3.—Per cent of digestible protein, 19.8:
300 pounds corn meal.
200 pounds cottonseed meal.
100 pounds dried distillers' grains (corn).
100 pounds gluten feed.

Mixture 4.—Per cent of digestible protein, 19.8:
- 200 pounds corn-and-cob meal.
- 100 pounds cottonseed meal.
- 100 pounds linseed meal (old process).

Mixture 5.—Per cent of digestible protein, 18.8:
- 200 pounds corn meal.
- 150 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds wheat bran.

Mixture 6.—Per cent of digestible protein, 18.1:
- 200 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds oats, ground.
- 100 pounds linseed meal (old process).

Mixture 7.—Per cent of digestible protein, 19.4:
- 400 pounds corn meal.
- 200 pounds cottonseed meal.
- 300 pounds gluten feed.
- 400 pounds dried brewers' grains.

Mixture 8.—Per cent of digestible protein, 18.3:
- 200 pounds corn meal.
- 100 pounds linseed meal (old process).
- 150 pounds gluten feed.
- 200 pounds dried brewers' grains.

Mixture 9.—Per cent of digestible protein, 18.4:
- 300 pounds corn-and-cob meal.
- 200 pounds cottonseed meal.

Mixture 10.—Per cent of digestible protein, 19.1:
- 200 pounds corn-and-cob meal.
- 100 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds buckwheat middlings.

Mixture 11.—Per cent of digestible protein, 19.1:
- 200 pounds barley.
- 200 pounds cottonseed meal.
- 100 pounds alfalfa meal.
- 100 pounds wheat bran.

WITH HIGH-PROTEIN ROUGHAGES.

With roughage of the high-protein class, such as clover, alfalfa, soy beans, cowpeas, and vetch or other legume hay, the following grain mixtures may be used:

Mixture 12.—Per cent of digestible protein, 14.1:
- 400 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds wheat bran.

Mixture 13.—Per cent of digestible protein, 15.6:
- 400 pounds corn meal.
- 200 pounds gluten feed.
- 200 pounds linseed meal (old process).
- 100 pounds oats, ground.

Mixture 14.—Per cent of digestible protein, 14.9:
- 200 pounds corn meal.
- 200 pounds gluten feed.
- 100 pounds malt sprouts.
- 100 pounds wheat bran.

Mixture 15.—Per cent of digestible protein, 16.7:
- 300 pounds barley.
- 100 pounds cottonseed meal.
- 100 pounds alfalfa meal.
- 100 pounds wheat bran.

Mixture 16.—Per cent of digestible protein, 13.7:
- 100 pounds barley.
- 200 pounds coconut meal.
- 100 pounds oats, ground.
- 100 pounds wheat bran.

Mixture 17.—Per cent of digestible protein, 15.8:
- 300 pounds corn-and-cob meal.
- 200 pounds gluten feed.
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

Mixture 18.—Per cent of digestible protein, 15.5:
- 100 pounds corn meal.
- 100 pounds linseed meal (old process).
- 100 pounds oats, ground.

WITH COMBINATION OF LOW AND HIGH PROTEIN ROUGHAGES.

The following grain mixtures are adapted for feeding with a combination of the low and high protein classes of roughage, such as silage and clover, or other legume hay; corn stover and clover, or other legume hay; mixed hay, or oat-and-pea hay, etc.:

Mixture 19.—Per cent of digestible protein, 16.3:
- 400 pounds corn meal.
- 300 pounds dried distillers' grains (corn).
- 100 pounds gluten feed.
- 100 pounds linseed meal (old process).

Mixture 20.—Per cent of digestible protein, 16.1:
- 300 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds linseed meal (old process).
- 200 pounds wheat bran.

Mixture 21.—Per cent of digestible protein, 16.4:
- 400 pounds corn meal.
- 100 pounds cottonseed meal.
- 200 pounds dried distillers' grains (corn).
- 100 pounds gluten feed.

Mixture 22.—Per cent of digestible protein, 16.7:
- 400 pounds corn meal.
- 100 pounds cottonseed meal.
- 200 pounds gluten feed.
- 200 pounds dried brewers' grains.

Mixture 23.—Per cent of digestible protein, 16.4:
- 200 pounds corn-and-cob meal.
- 100 pounds cottonseed meal.

Mixture 24.—Per cent of digestible protein, 16.7:
- 200 pounds corn meal.
- 100 pounds peanut meal (with hulls).
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

Mixture 25.—Per cent of digestible protein, 16.4:
- 100 pounds corn meal.
- 100 pounds oats, ground.
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

The above-named mixtures which contain linseed meal are particularly adapted for use when no succulence is in the ration.

QUANTITIES OF ROUGHAGE AND GRAIN TO FEED.

In this connection the general principles brought out earlier in the discussion should always be kept in mind, namely, that economical feeding demands that the cows be fed to full capacity. To do this and to have the best effect on the individual cow requires a thorough knowledge of feeds and of cows. To give a few practical rules to guide the beginner in obtaining this knowledge is all that has been attempted in this publication. Rules of this nature in reference to the quantities to feed will not be out of place.

1. *Under most circumstances the cow should be fed all the roughage that she will eat up clean, adjusting the grain ration to the milk production. Only when the cow tends to become overfat should the quantity of roughage be restricted.*

2. *A grain mixture should be fed in the proportion of 1 pound to each 3 pints or pounds of milk produced daily by the cow, except in the case of a cow producing a flow of 40 pounds or more, when the ration can be 1 pound to each 3½ or 4 pounds of milk. An even better rule is 1 pound of grain each day for every pound of butter fat produced during the week by the cow.*

3. *Feed all the cow will respond to in milk production. When she begins to put on flesh, cut down the grain.*

INDIVIDUAL FEEDING.

Different cows have different capacities for converting feed into milk. For this reason the above-mentioned rules can serve only as indicators for the inexperienced feeder. No man who has not a full appreciation of the wide variation in individual cows will be fully successful as a feeder. Some cows may have natural capacity for producing large quantities of milk, and may not receive feed enough for maximum production. By increasing the feed of the highest-producing cows and carefully consulting the milk sheets on which each cow's daily production is recorded, the skillful feeder will soon find that some cows in the herd will respond to the increased allowance and return a good profit on the additional feed given. On the other hand, there are cows that have a limited capacity for milk production and are very liable to be overfed. By carefully studying each individual cow the feeder will soon ascertain the point beyond which any addition to the grain ration becomes unprofitable.

WATER FOR COWS.

All animals require plenty of good, pure water. This is especially true of the milking cow, as water constitutes more than three-fourths of the total volume of milk. The water supply, therefore, demands the dairyman's most careful attention. Stale or impure water is distasteful to the cow and she will not drink enough for maximum milk production. Such water may also carry disease germs which might make the milk unsafe for human consumption or be dangerous to the cow herself. During the winter, when cows are stabled the greater part of the time, they should be watered two or three times a day unless arrangements have been made to keep water before them at all times. The water should, if possible, be 15° or 20° above the freezing point, and should be supplied at practically the same temperature every day. When water well above freezing temperature is stored in tanks and piped directly to the cow, there is probably little occasion for facilities to warm it. When it stands in a tank on which ice often forms, it usually pays well to warm it slightly. This can be done by a tank heater, by live steam, or by hot water from a boiler. If a boiler is used for running a separator or for heating water to wash and sterilize utensils, steam from it can readily and cheaply be used to warm the water.

SALT.

Salt is required by all animals. The dairy cow requires an ounce or more a day, and while she should be given all she needs, she should not be forced to take more than she wants. It is best, therefore, to give only a small quantity on the feed, and to place rock salt in boxes in the yard where she can lick it at will.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN

WASHINGTON, D. C. 744 SEPTEMBER 21, 1916

Contribution from the Forest Service, H. S. Graves, Forester.

THE PRESERVATIVE TREATMENT OF FARM TIMBERS

[Revised, 1915]

By GEORGE M. HUNT, *Chemist in Forest Products, Forest Products Laboratory.*

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INTRODUCTION.

The amount of wood used on the farms of the country and exposed to decay is very great. The total is difficult to estimate, but it undoubtedly amounts to several billion feet. This wood is used in various forms, such as fence posts, building foundations, windmill frames, shingles, telephone poles, silos, etc. For such uses durability is usually the chief requisite.

Some woods resist decay more than others. A post of one kind of wood may last 10 years or more, while one of another kind may last only two years under the same conditions. There is also a great difference in the durability of wood of the same species under different conditions. In a very wet or a very dry situation a post will last longer than in a situation where the ground is simply damp. It will last better in a compact clayey soil than in a loose sandy soil. A warm, moist climate is more favorable to decay than a dry one, or one that has long, cold winters.

Naturally durable woods are continually growing scarcer and higher priced in most localities, and less durable woods must be used in their stead. Many of these woods in their natural condition

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NOTE.—This bulletin is of value to all who are interested in prolonging the life of building timbers, poles, and posts, especially on farms at a distance from preservative works.

will last only two or three years in situations favorable to decay. It will readily be seen, therefore, that any reasonably cheap method of increasing their life will effect a material saving to the user.

For a number of years the Forest Service has been conducting experiments on the preservative treatment of fence posts, poles, and other forms of timber exposed to decay. These experiments have been made in cooperation with agricultural experiment stations, farmers, and various companies, and also upon the National Forests. They have proved conclusively that when a suitable preservative treatment is given the resistance of wood to decay can be very much increased.

DECAY.

Decay is not due to the chemical action of the soil or to the fermentation of the sap, but is the result of the action of certain low forms of plant life called fungi. These consist, for the most part, of very fine thread-like filaments, collectively called mycelium, which penetrate the wood in all directions. Certain substances in the wood constitute the food of the fungi. As these substances are dissolved the structure is broken down, until the wood reaches the condition commonly known as rotten.

The mycelium usually grows out to the surface to form compact masses called fruiting bodies. Since there are many kinds of fungi, there are many kinds of fruiting bodies. The various forms of "toadstools," "punks," "brackets," or "dog ears," which are so frequently found growing on trees and deadwood, are examples of these (see figs. 1 to 4). Their presence generally means that decay has made considerable progress in the wood. The function of all fruiting bodies is to produce spores, which are to the fungus what seeds are to higher plants. Millions of spores may be produced by a single fruiting body, and they are so small that they are able to float long distances in the air. When a spore drops into a crack in a piece of wood and conditions are favorable, it germinates and the fungus begins its destructive action.

Another way in which decay spreads is by the mycelium growing from one piece of wood to another. When a piece of decaying wood is in contact with a sound piece the latter may rapidly become infected in this way and be ruined.

The four requirements for the growth of fungi are moisture, air, a favorable temperature, and food.

A damp condition of the wood is probably the most favorable to decay. Wood can be either so wet or so dry that the fungi can not live in it. When submerged in water it has been known to last hundreds of years, and in perfectly dry situations it will often last indefinitely. Wood in contact with damp ground usually contains the right amount of moisture for the development of decay. Also, where timber is in contact with wood or other material, water frequently collects in the joints and keeps the wood moist for long periods of time, thus favoring decay at these points. Familiar examples of this are decay in the tops of posts in board fences (see fig. 5), in the joints of various kinds of buildings (see fig. 6), in porch columns, in sills resting on wood or stone piers, and in lumber piles.

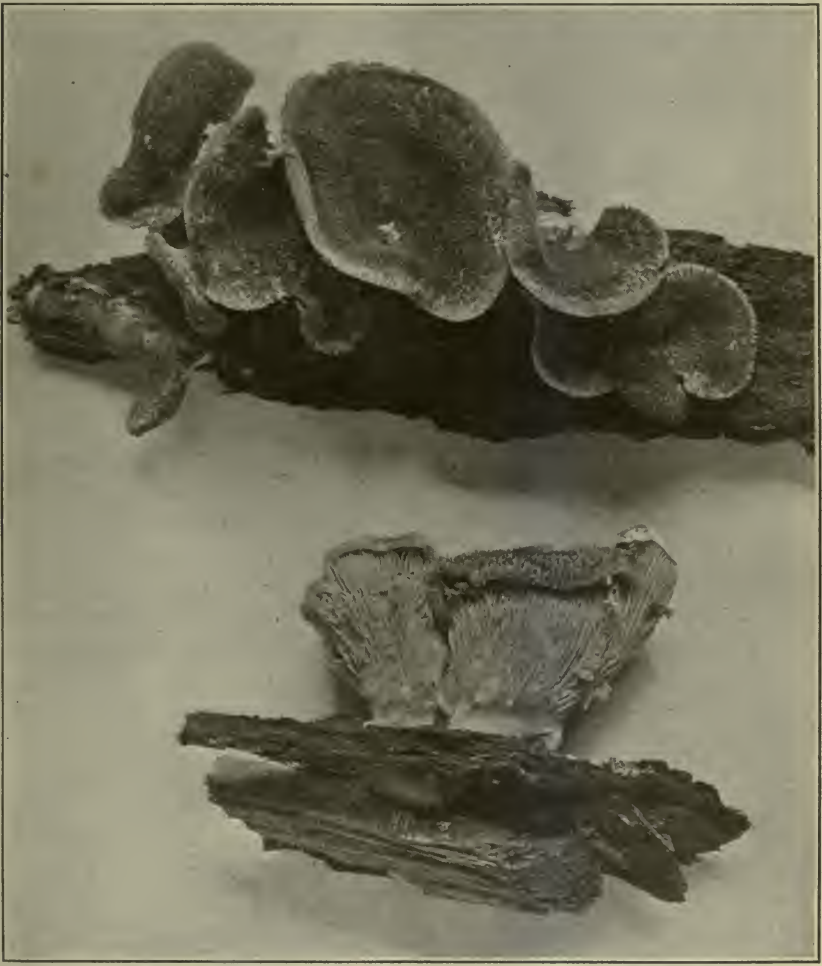

FIG. 1.—Fruiting body of fungus, *Lentinus lecomtei.*

There are very few places where the fungus can not get air enough for its needs. When wood is buried deep in the ground, especially in compact or clayey soil, it tends to become saturated with moisture, so that decay is prevented; but within 2 or 3 feet of the surface of the ground there is usually enough air for the growth of the fungus. Conditions are most favorable, of course, just at the surface of the ground; and it will be noted that the point of greatest decay in a fence post is usually near the ground line. Above the ground line moisture conditions are usually unfavorable, and below the ground line the air supply is less favorable for the development of decay. In loose or sandy soils, however, which under good drainage contain more air than compact soils, decay may extend to the bottom of the post.

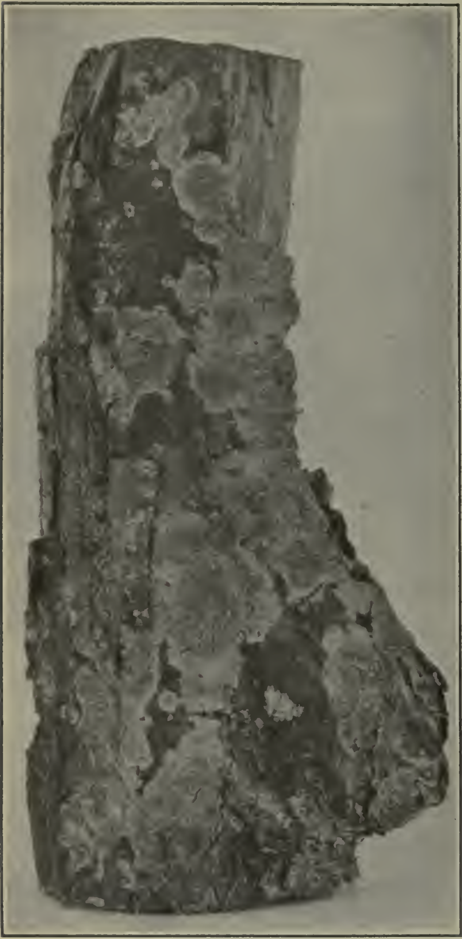

FIG. 2.—Fruiting body of fungus, *Poria sp.*

Wood-destroying fungi can not grow at very high or very low temperatures; but there are few, if any, climates in which the temperature during at least part of the year is not favorable to their growth.

The wood itself supplies the fourth requirement of the fungi, which is food. In order to prevent decay, it is necessary to deprive the fungus of one or more of these four requirements. It is out of the question in ordinary situations to deprive it of air and warmth; and though moisture can sometimes be eliminated to a certain extent, this can not be done when the wood is exposed to the weather. In general, therefore, the most effective method of preventing decay is to poison the food supply; and upon this principle is based the use of most successful wood preservatives.

PROLONGING THE LIFE OF POSTS WITHOUT THE USE OF PRESERVATIVES.

PEELING.

Posts which are to be set without preservative treatment should always be peeled. The presence of loose bark allows moisture to collect, and thus makes conditions favorable to decay. It also harbors wood-boring insects, which, by boring tunnels, may both seriously weaken the post and make conditions more favorable for rapid decay by affording easy access to fungi.

SEASONING.

The general impression has been that seasoning wood makes it more durable. In a number of experiments made by the Forest Service on poles and ties, however, green wood has been found as durable as seasoned wood. It is questionable, therefore, if it pays to season posts simply to increase their durability. If the posts are to be used in moist locations, the seasoned wood can quickly take up moisture and in a comparatively short time reach the condition of green wood. In any case, the seasoned posts will in time reach approximately the same condition as unseasoned posts under the same conditions.

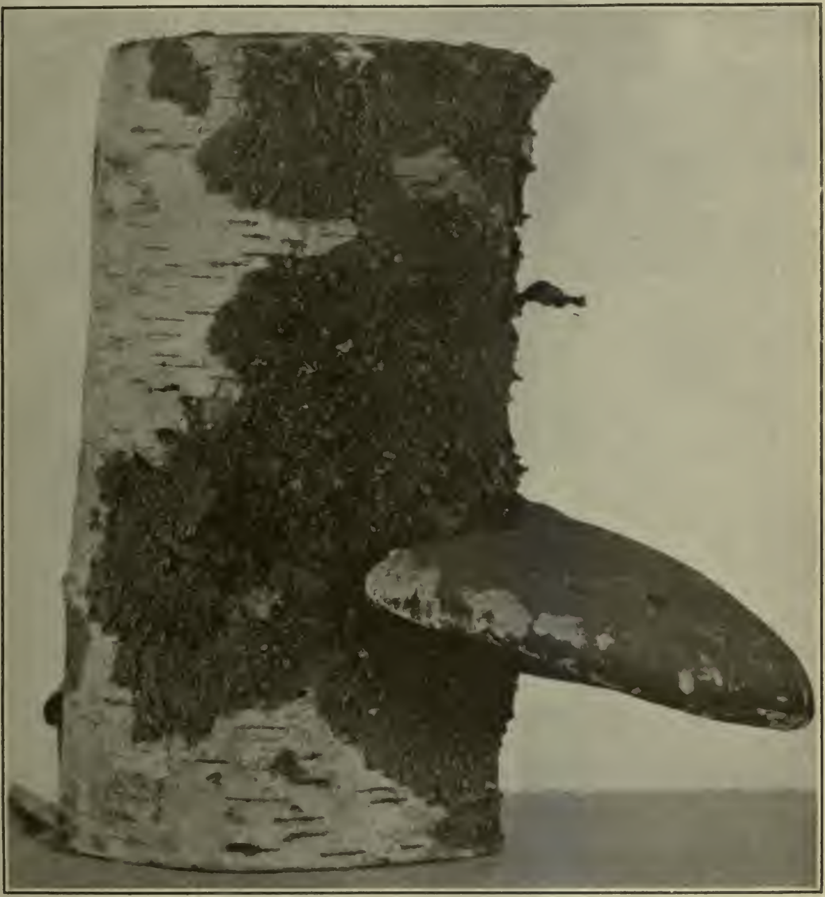

FIG. 3.—Fruiting body of fungus, *Polyporus betulinus.*

In order to be of any value seasoning must be properly done, and the posts must not be held so long that decay begins before they are set. The instructions for seasoning given on pages 11 to 12 should be followed. Posts should never be left close piled for any length of time.

CHARRING.

In some cases charring has appeared to give good results; in others, however, it has failed to give any appreciable protection, and it can not be relied upon.

STONES.

Piling stones around the base of the post has sometimes been resorted to. This tends to keep back the weeds and allow the air to circulate freely around the post. In some climates, however, where the ground is wet during a considerable portion of the year, the use of stones in this way has seemed to favor decay rather than retard it, because the post is allowed to dry out partially between wet spells. It would be better to keep it constantly wet.

FIG. 4.—Fruiting body of fungus, *Fomes pinicola.*

In dry sandy regions posts are sometimes very badly cut by drifting sand being blown against the wood. This effect is sometimes called "burning." Piling stones around such posts would, no doubt, be effective in preventing the sand-cutting. It is doubtful, however, if results obtained by the use of stones for the sole purpose of preventing decay will justify the labor involved.

SETTING IN CONCRETE.

Setting posts in concrete may have a beneficial effect in some cases. If moisture should reach the post, however, it may be held there by the concrete and cause decay to proceed more rapidly. This is an expensive method of setting posts and can not be depended upon to prevent decay.

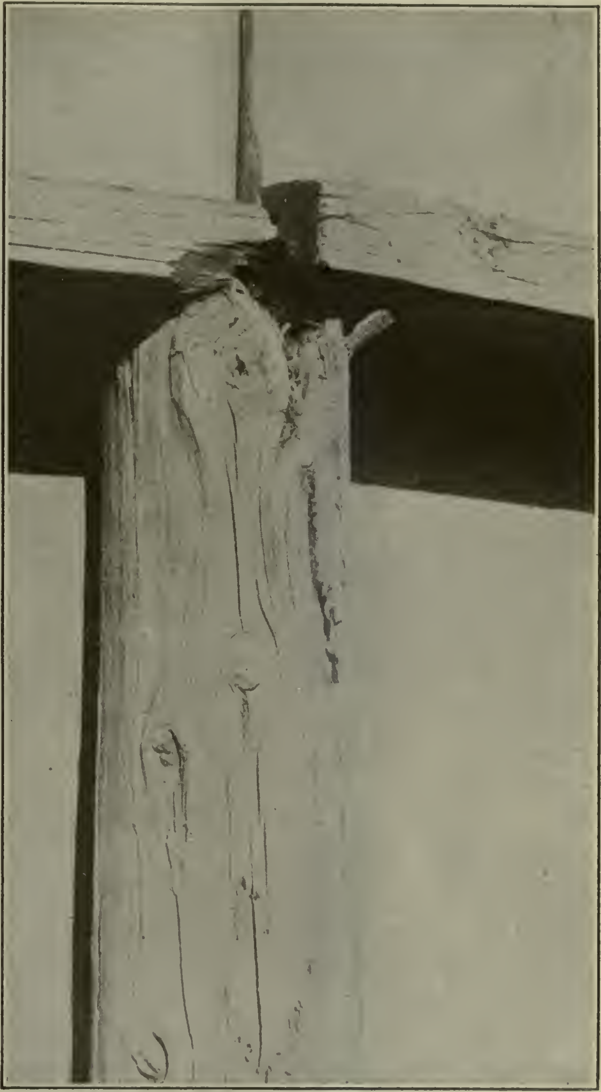

Fig. 5.—Decay in top of fence post and adjacent stringers due to collection of moisture.

PROLONGING THE LIFE OF POSTS BY MEANS OF PRESERVATIVES.

REQUIREMENTS OF PRESERVATIVES.

There are five chief requirements for a preservative for general use. It should be reasonably cheap, should penetrate wood readily, should not be corrosive to metal, should not evaporate or wash out of the wood easily, and should be poisonous to fungi. For special purposes there are, of course, additional requirements.

VALUE OF VARIOUS PRESERVATIVES.

COAL-TAR CREOSOTE.

Coal-tar creosote, which is a brownish-black heavy oil, practically insoluble in water, is in general use for preserving fence posts and other farm timbers. Satisfactory penetrations of many species of wood can be secured with it, and excellent results have been obtained by its use. It is considered one of the most efficient preservatives against decay so far developed for farm timbers exposed to the weather. It may also be used for inside work wherever its color, odor, and other properties are not objectionable.

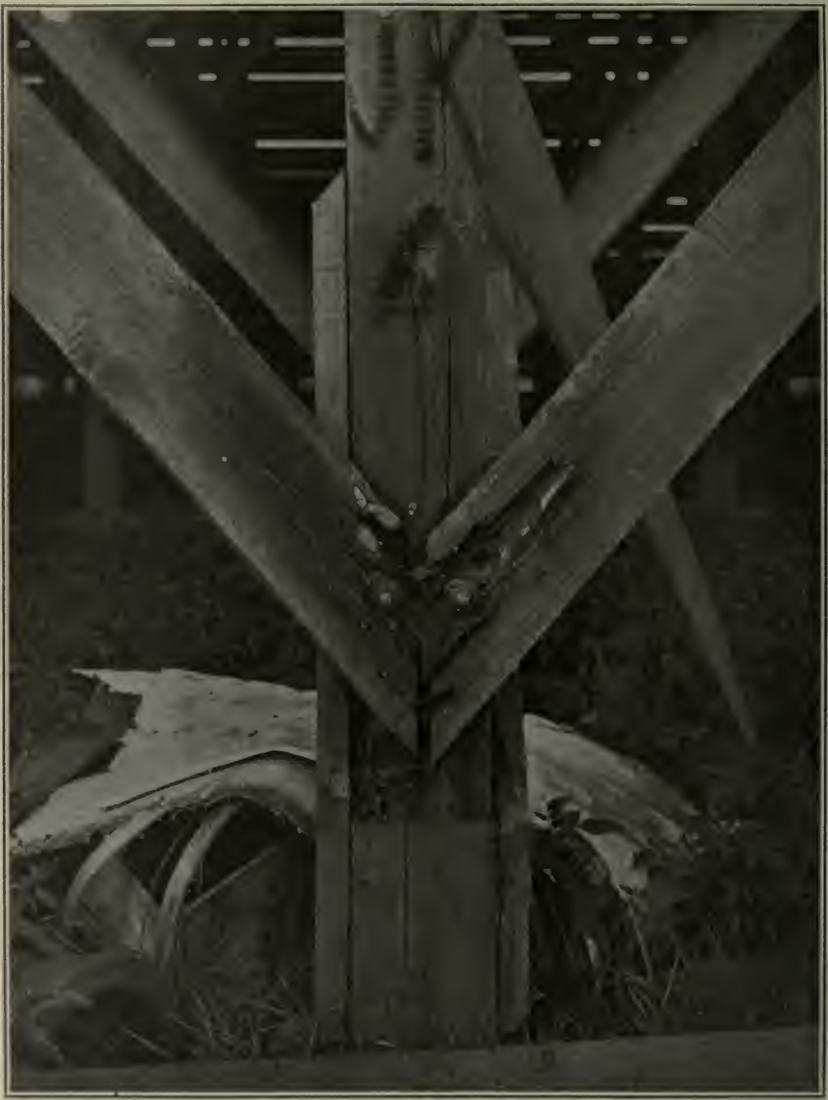

FIG. 6.—Decay in braces at a joint where moisture has collected.

Coal-tar creosotes vary considerably in quality; but satisfactory results may be obtained from any good grade, provided a sufficient amount is put into the wood and a good penetration is secured. Creosotes containing a high percentage of oils which boil at a low temperature are not so suitable for use on the farm as those which contain a lower percentage of these oils, because a considerable portion may evaporate and be lost during treatment. In some cases as much as one-fifth of the oil used has been lost in this way. This loss of oil by evaporation may be largely offset, however, by the lower price at which the low-boiling creosotes may usually be obtained. The increase in price which can be economically paid for the higher-boiling creosotes will in general not be more than from 25 to 35 per cent. Generally, when a considerable amount of creosote is to be used, it is purchased under specifications. If required, further information on this point can be obtained from the Forest Products Laboratory, Madison, Wis.

CARBOLINEUMS.

Carbolineums are proprietary preservatives similar in appearance and preservative qualities to coal-tar creosote, but usually higher in price. In service tests made by the Forest Service on brush-treated telephone poles they have given about the same increase in durability as coal-tar creosote.

WOOD-TAR CREOSOTES.

But little reliable data upon the effectiveness of wood-tar creosotes is available, and until satisfactory service tests are completed no definite recommendation can be made. It is likely, however, that good results will be obtained if the wood creosote is of a high grade.

WATER-GAS-TAR CREOSOTE.

Water-gas-tar creosote is an oil similar in many ways to coal-tar creosote, but its value as a fence-post preservative has not been fully established. It is possible that good results would be obtained from its use in open-tank work.

ZINC CHLORIDE.

Zinc chloride is a toxic preservative that gives good results when properly applied and used under the right conditions. It is sold in solid form or in a 50 per cent solution, and is injected into the wood in a solution of from 2 to 5 per cent in water. It is much cheaper than coal-tar creosote. On account of its solubility in water, however, it is washed out of wood in time by the rain or ground water, which is the chief objection to its use.

In general, zinc chloride is not considered as satisfactory for farm timbers as coal-tar creosote, but there may be cases where its use is advisable. For wood to be used indoors it may in some cases be satisfactory where creosote would be objectionable on account of its odor, color, etc. It is not recommended, however, for use by the brush method.

TAR.

Tar is not a good preservative for farm use; and, in general, good results have not been obtained with it when applied by methods that are practicable on the farm. Its chief defect is that it does not penetrate the wood readily. Coal-tar and water-gas tar are also much less poisonous to the organisms which cause decay than is coal-tar creosote.

CRUDE OIL.

Crude oil is not sufficiently poisonous for a wood preservative. If the wood can be thoroughly saturated with it, water may be kept out and decay prevented; but it is very difficult, if not impossible, to get enough oil into most woods by processes which are practicable on the farm. For treating by the brush method crude oil is entirely unsatisfactory.

PAINT, LINSEED OIL, WHITEWASH.

Good results can not, in general, be expected from paint, linseed oil, or whitewash when used on fence posts or other timbers in contact with the ground. They do not penetrate the wood deeply, and the only way they can prevent decay is by preventing the entrance of fungi or moisture into the wood. Furthermore, the wood is seldom painted on all sides; so it is usually possible for fungus to enter through an unpainted part. Whenever, the painted film cracks or peels off, decay can also enter. It is quite common to see wood decaying beneath a coat of paint. (See figs. 5 and 7). If the wood were saturated with linseed oil it might prevent decay by keeping out the water; but this would be difficult to accomplish as well as being too expensive.

CEMENT COATINGS.

Posts have sometimes been dipped in thin cement and allowed to dry, leaving a coat of cement over the surface of the wood. Such a coating will not keep out water and is easily cracked or broken off. Good results can not be expected from this treatment.

PREPARATION OF TIMBER FOR TREATMENT.

Only sound wood is fit for treatment. If decay has made a start, it is not always entirely stopped by the treatment, but may continue beneath the treated wood until the interior of the post is destroyed. The first thing to consider, then, is the selection and preparation of the timber.

PEELING.

All timber should be peeled and thoroughly seasoned before the preservative is applied. In peeling posts of pine, cedar, and other coniferous woods, care should be taken to remove the thin inner bark from the part of the post that is to be treated. Even small patches of this bark often prevent penetration by the preservative.

(See fig. 8.) When the bark drops off, a patch of untreated or poorly treated wood is exposed, and the opportunity is offered for decay to enter. The effectiveness of the treatment depends on maintaining an unbroken area of treated wood entirely around the post. In some of the hardwoods strips of bark do not retard penetration so seriously.

BEVELING TOPS.

Beveling the tops of posts to a sharp edge, so that snow and water can readily drain off, is held by some to increase the durability of the tops. Theoretically this is a good practice, but there seems to be little definite proof that it results in an appreciable increase in durability.

SEASONING.

In order to obtain the best absorption and penetration of preservative the posts must be seasoned. The water and sap must come out of the wood to make room for the preservative to go in. Furthermore, wood treated green is likely to check open after treatment, exposing untreated wood. Seasoned wood which has been wet by recent rains is not in good condition to treat.

The best place for rapid seasoning is an exposed location on high ground. On damp or low ground or near a stream seasoning will take place much more slowly, and the wood will never get quite so dry. If properly piled in a good location, posts will usually season sufficiently for treatment in from 60 to 90 days of good seasoning weather. In exceptional cases they have been known to season in a month.

It is sometimes difficult to determine from its appearance whether timber is sufficiently seasoned or not. By weighing a few representative posts at regular intervals it is possible to determine the degree of seasoning very closely. When an ordinary sized post properly piled for seasoning does not lose more than a pound or two in weight during a week of good seasoning weather it may be considered dry enough to treat.

CHECKING.

Some woods, such as oak and chestnut, check very badly when dried too rapidly. It is well, if possible, to cut and peel such timber in the fall or winter, so that by the time warm weather comes it will be partially seasoned. Woods like pines, firs, etc., are usually not affected so seriously as the oaks by rapid seasoning.

PILING.

The posts should be open piled, so that the air will circulate freely around each one. The bottom of the pile should be raised 6 inches or a foot from the ground. Figure 9 illustrates a good method of piling. Another method, but somewhat less desirable because one end of each post is on the ground, is illustrated in figure 10. If the ground is dry, the posts can be seasoned where they are cut by laying them upon rocks or brush, or keeping them off the ground in any other way. Posts should never be piled in close piles or allowed to lie on the ground; for under such conditions they will frequently start to decay before they are seasoned. (See figs. 11 and 12.)

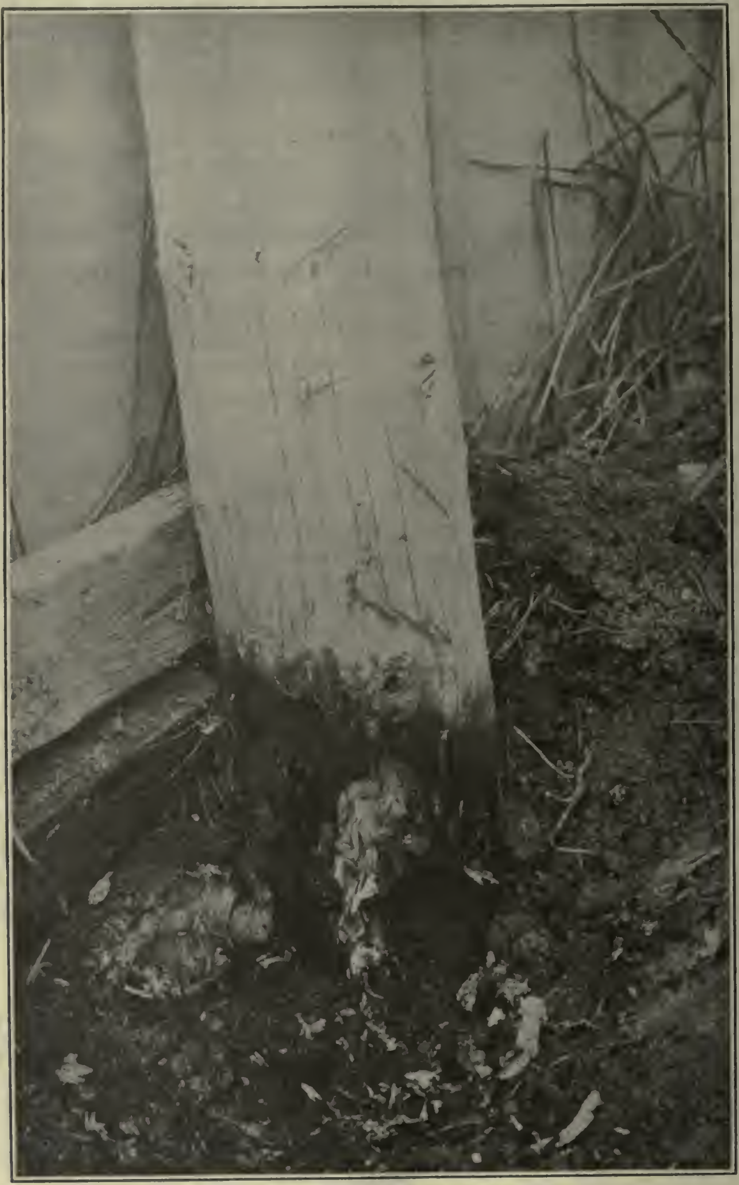

FIG. 7.—Painted post decayed at the ground line.

METHODS OF APPLYING PRESERVATIVES.

There are a number of methods of applying preservatives to wood, and they differ considerably in cost and effectiveness.

PRESSURE PROCESSES.

Impregnation under pressure is the most satisfactory means of injecting preservatives into wood. The various pressure processes differ in details, but the general principle is the same in all cases. The wood is placed in steel cars and run into a long steel cylinder. This is closed and the preservative is pumped in. Pressure is then applied until the desired quantity of preservative has been absorbed by the wood. There are over 90 plants in the United States using pressure processes, and millions of gallons of coal-tar creosote, zinc chloride solution, and mixtures of the two are used each year. It would be well for anyone living within reach of such a plant to consider having his timber treated there, if satisfactory arrangements can be made; for a good pressure treatment will usually be more effective than any treatment that can be made on the farm.

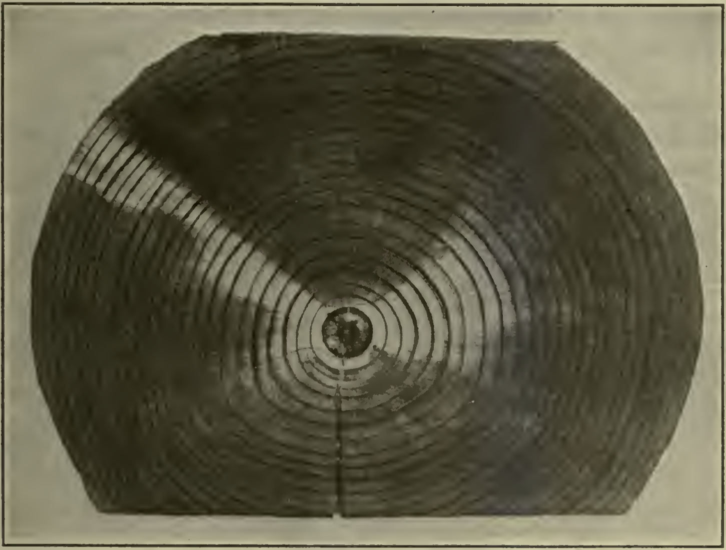

FIG. 8.—Treated pine tie. The light streak shows where penetration has been retarded by a strip of bark.

THE OPEN-TANK PROCESS.

The open-tank process is the most thorough method of treatment that is practicable on the farm. The posts are heated for one or more hours in the preservative (usually coal-tar creosote) at a temperature of from 180° to 220° F. They are then quickly transferred to a tank of oil having a temperature of about 100° F., and are left there for one hour or more. In the hot bath the air and moisture in the wood expand and are partially driven out. When the wood is plunged into the cool oil the air and moisture in it contract and draw the oil into the wood. Except in the case of a few very easily treated woods, there is little absorption of oil by the wood during the hot bath. Instead of a separate tank being used for the cool bath, the heating of the oil in the hot bath may be stopped and the wood and the oil allowed to cool together. This accomplishes the same purpose as the cool bath; but a longer time is required because the hot oil cools very slowly. The single-tank treatment is particularly suitable for heavy posts or poles which can not be easily transferred from one tank to the other. It can sometimes be used to advantage also by heating for two or three hours early in the morning or in the evening and allowing the posts to cool all day or all night. This will make it possible to carry on the treatment without interference with the regular work of the farm. The posts may be treated more rapidly, however, by using the two tanks.

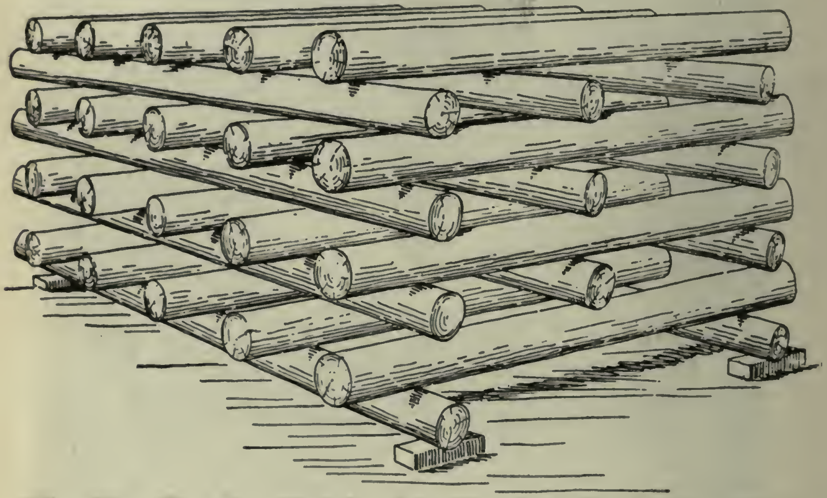

FIG. 9.—A good way to season posts.

It is desirable in the open-tank treatment to have the sapwood penetrated all the way through by the oil. This is sometimes very difficult to accomplish, however, or requires too much oil, and a shallower penetration must then be accepted. A penetration of from one-half to three-fourths of an inch should give very good results. Even lighter penetrations, though they are not recommended, will probably give sufficient protection to pay for the cost of treating. The treatment should extend far enough up the post so that at least 6 inches of treated wood will be above the ground line when the post is set. During the cooling period the absorption of oil by the posts will lower the height of the oil in the tank. Care should, therefore, be taken to see that there is always enough oil in the tank to submerge the posts to the proper depth.

The length of time the wood is held in the hot and cold baths should be determined by the penetration obtained and the amount of oil absorbed. The best treatment is the one that gives the greatest penetration with the least absorption of oil. The penetration may be determined by boring a small hole at the point where the ground line will be. This hole should be tightly plugged with a creosoted plug before the post is set. The reason for taking the penetration at the ground line is that this is the point at which decay is usually most severe, and, therefore, the point at which depth of treatment is most important.

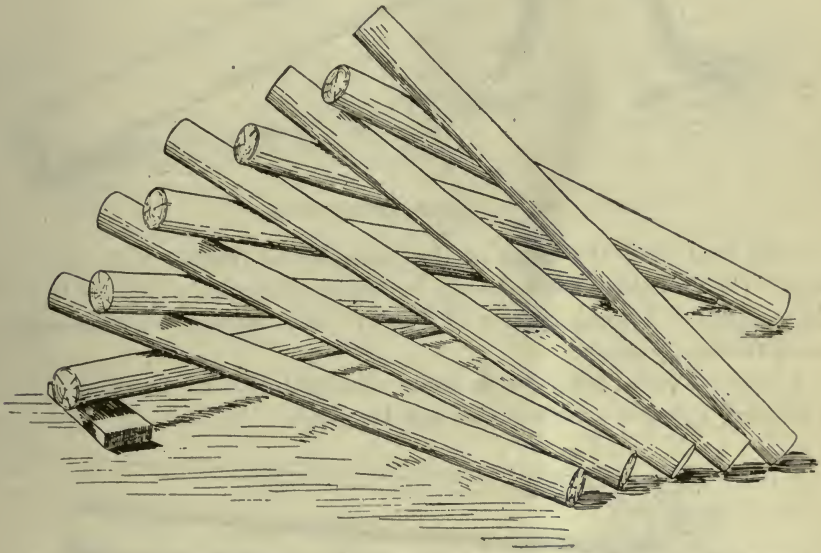

FIG. 10.—Another method of piling posts to season. Not so satisfactory as that shown in figure 9.

Ordinarily it will not be necessary to leave the posts in the hot bath over 3 hours, and, in many cases, a much shorter time may give good results. The same is true of the cold bath. If the penetration of oil is not sufficient, either the hot or the cold bath should be lengthened. If the penetration is satisfactory, but too much oil is absorbed, the cold or cooling bath should be shortened. Green or partly seasoned posts or posts wet from recent rains require a much longer hot bath than seasoned dry ones. The amount of oil absorbed per post will vary with the kind of wood and the size of the post. In general, it should be between four and six tenths of a gallon for a post of from 5 to 6 inches in diameter.

During the heating period the temperature of the creosote should be kept as nearly constant as possible; or, still better, it should be allowed to increase very slowly. It should not be allowed to fluctuate up and down, if this can be helped. Temperatures between 200° and 220° F. are satisfactory. For timber which treats very easily 180° may prove high enough. The temperature should not be allowed to go above 220°, as a certain amount of the oil is lost by evaporation at high temperatures. There is also danger that the oil will boil over the sides of the tank if the temperature gets too high. The "cold" bath should be warm enough to liquefy the oil thoroughly. A temperature of 100° F. will usually be found sufficient for this purpose.

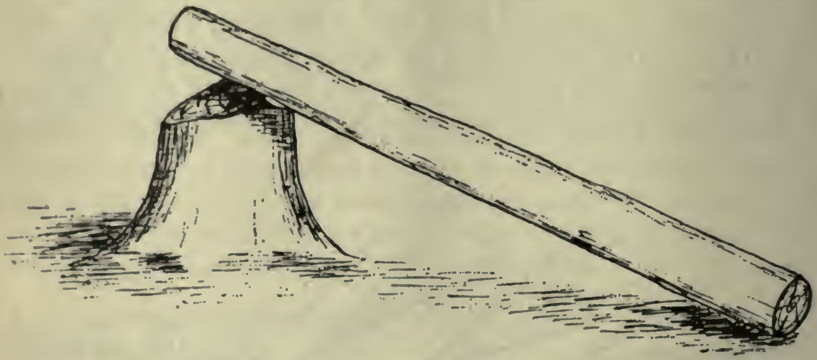

FIG. 11.—Seasoning against a stump.

Various woods differ so in their susceptibility to treatment that a general rule for treating can not be given. In Table 1, however, are shown the results obtained in some experiments with a number of kinds of wood.

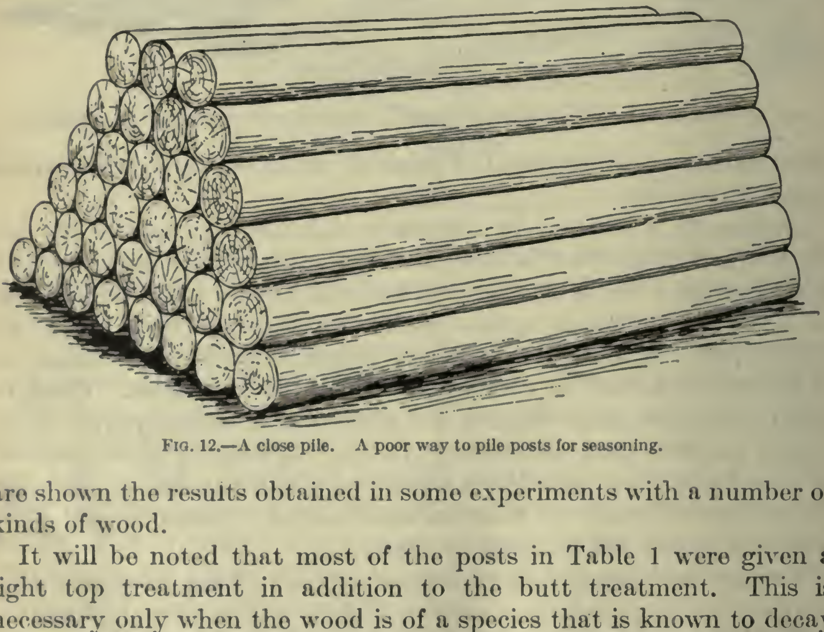

FIG. 12.—A close pile. A poor way to pile posts for seasoning.

It will be noted that most of the posts in Table 1 were given a light top treatment in addition to the butt treatment. This is necessary only when the wood is of a species that is known to decay rapidly even above the ground line, or when the climate is warm and moist, as that in some of the southern States. The tops, however, do not require as heavy treatment as the butts.

TABLE 1.—*Results secured in the treatment of various woods.*

[All posts were round, peeled, and seasoned.]

Species.	Absorption per 5-inch post.	Penetration.		Single-tank treatment.			Double-tank treatment.	
		2 feet from butt.	2 feet from top.	Butt.		Top.	Hot oil.	Cold oil.
				Hot oil.	Cooling oil.			
	Galls.	*In.*	*In.*	*Hrs.*	*Hrs.*		*H. min.*	*H. min.*
Ash, white	0.4	0.4	....	5	12	Dipped[a]	....	....
Basswood	.6	.1	0.05	....	....	....	1	30
Beech	.6	1.0	.4	....	....	....	1	45
Birch, river	.6	.7	.3	....	....	....	3	1
Butternut	.4	[b] .5	....	6	12	....	....	....
Elm, slippery	.6	[b] .3	.1	....	....	....	1 30	1 30
Elm, white	.4	[b] .4	....	6	12	....	....	....
Gum, black	.6	.6	.3	....	....	....	1	1
Gum, cotton (tupelo)	.6	.6	.3	....	....	....	1	1
Gum, sweet (red)	.6	1.0	.3	....	....	....	1	45
Hickory, bitternut	.4	.5	....	6	12	Dipped[a]	....	....
Magnolia, sweet (bay)	.6	.4	.2	....	....	....	1	30
Maple, red	.6	1.0	.3	....	....	....	4	2
Maple, sugar	.6	.2	.1	....	....	....	3	2
Oak, pin	.5	[b] 1.0	.5	....	....	....	1	45
Oak, red	.4	[b] .5	.3	....	....	....	1	45
Pine, loblolly	.5	1.5	1.0	....	....	....	1 30	1
Pine, lodgepole	.6	1.2	.6	....	....	....	1 30	1
Pine, pitch	.5	1.0	.3	....	....	....	3	1
Pine, scrub	.5	1.0	.4	....	....	....	3	2
Pine, shortleaf	.5	1.0	.3	....	....	....	3	1
Pine, western yellow[c]	.5	.7	....	....	....	....	2 30	{ 1 30 2
Poplar, white	.5	.5	.2	....	....	....	6	12
Sycamore	.6	1.0	.2	....	....	....	1	30
Tulip tree	.6	.4	.1	....	....	....	2	30
Willow, white[d]	.6	.6	.2	....	....	....	4	1

[a] Dipped for 5 minutes or more.
[b] Width of sapwood. Penetration limited by impenetrable heart.
[c] Average results from 6,000 posts.
[d] Requires especially thorough seasoning.

There are two methods of giving the top treatment. In one method the cold tank is made long enough to hold the posts lying full length. In this case, when the posts are transferred to the cold tank, they are entirely submerged in the oil. This results in a comparatively heavy absorption in the butts, which have been heated, but only a light absorption in the tops. Another method is to complete the butt treatment of the posts first, and then turn them upside down in a tank of hot oil and allow them to remain for a few minutes. The oil should be deep enough in the tank to cover all the post not treated before. If this is not possible, a swab should be used to souse the oil all over the wood not submerged. The swab can be made by tying a piece of burlap on a stick. Particular pains should be taken to fill all checks and cracks with the oil.

Sometimes, in seasoning, the outer surface of the wood becomes hard and has a glazed appearance. This effect is called "casehardening," and it may seriously retard penetration by the oil. The remedy is to shave off the hardened surface with a draw-shave for from 6 to 8 inches above and below the ground line. The rest of the butt need not be shaved.

After treatment it is a good plan to stand the posts upside down. This allows any excess oil in the butts to flow toward the top and stay in the wood, instead of dripping on the ground. They should not be left in this position more than a few weeks, especially if the tops are untreated, as decay may start in the part which touches the ground.

APPARATUS FOR OPEN-TANK PROCESS.

Various forms of apparatus are used in open-tank treatments. The essential parts of the apparatus for general farm use are one or two tanks (depending on whether the hot and cold or hot and cooling method is used), a thermometer, and some means of heating.

The chief requirements of the tanks are: (1) that they shall be strong enough to hold the weight of the oil and the posts; (2) that they shall not leak; (3) that they shall be deep enough so that the top of the oil will be a foot or more below the top of the tank during treatment; and (4) that they may be readily heated. Any tank of convenient size which will satisfy these requirements will do. The heating may be accomplished by a fire beneath the tank, or by means of steam coils, if steam is available. If an open fire is used, care should be taken to prevent the oil from slopping over the side of the tank and taking fire. This is the reason for having the top of the oil a foot below the top of the tank. Though the oil is not dangerously inflammable, and ordinary care will prevent trouble, carelessness may result in the loss of the oil and the posts. The treatment should be made, of course, in a situation where an accidental fire will not endanger any buildings.

In figure 13 is shown a plant made from oil drums by cutting out one head of each drum. In order to keep the posts from floating in the oil, it is well in a plant of this kind to use a false bottom in each drum, such as is shown in the figure. This can readily be made out of the heads cut from the drums, or any flat piece of iron, by riveting on strips of iron through which several screws protrude from one-half to three-fourths of an inch. The screws stick into the posts and keep them from moving about and floating in the oil.

Figure 14 shows a more permanent type of plant, in which the tank is made of comparatively heavy metal and is surrounded by a brick fire box.

Figure 15 shows a plant built for treating the entire post, giving a heavy butt treatment and a light top treatment. The horizontal tank is 8 feet long, 3 feet wide, and 3 feet deep; the round tank, about 3 feet in diameter and 4 feet deep. The pole and stand shown are for use in connection with the mortised board shown in the rear, to hold the posts under the oil during the cold bath.

In figure 16 the details of construction of the tanks used in one experimental plant are shown. This was a portable plant heated by steam, which was furnished by the boiler of a threshing engine. Between the steam pipes in the bottom of the tanks strips of 2-inch lumber studded with screws were placed and firmly wired to the pipes. The points of the screws projected about three-fourths of an inch above the wood and served to keep the posts from sliding about. Without the screws it would have been impossible to put a full charge of posts into the tank. On both sides of each tank, about 18 inches from the top, 2 by 12 inch planks were suspended by means of ⌝⊔-shaped irons which hooked over the sides of the tanks. This made a very satisfactory working platform. The capacity of the tanks was from 40 to 105 posts per charge, depending on the size and shape of the posts.

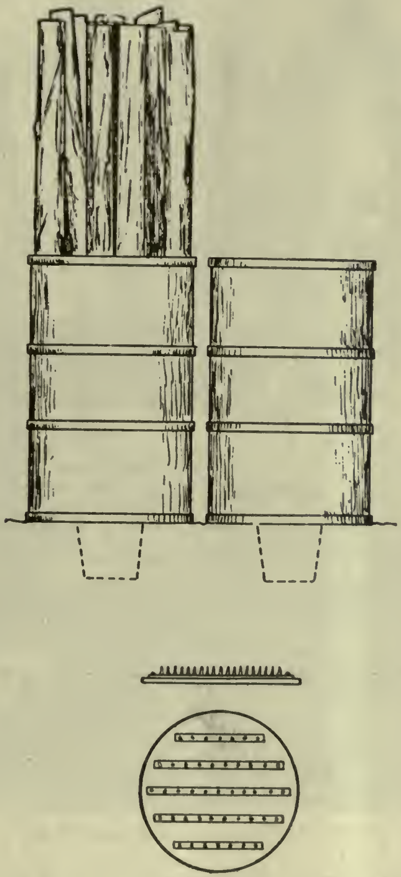

FIG. 13.—Treating plant made from two oil drums, showing method of constructing false bottom.

The number of posts to be treated should determine the character of the plant used. If only a few posts are to be treated, a simple plant similar to that shown in figure 13 is most suitable. For a large number of posts or timbers of other kinds, more elaborate apparatus is advisable, such as that shown in figure 16, or perhaps a stationary plant with a complete equipment of a steam boiler, storage tanks, oil pumps, a derrick for lifting the timber, etc. In any kind of a plant the ingenuity of the operator will be called upon to provide platforms and other means of handling the posts to the best advantage.

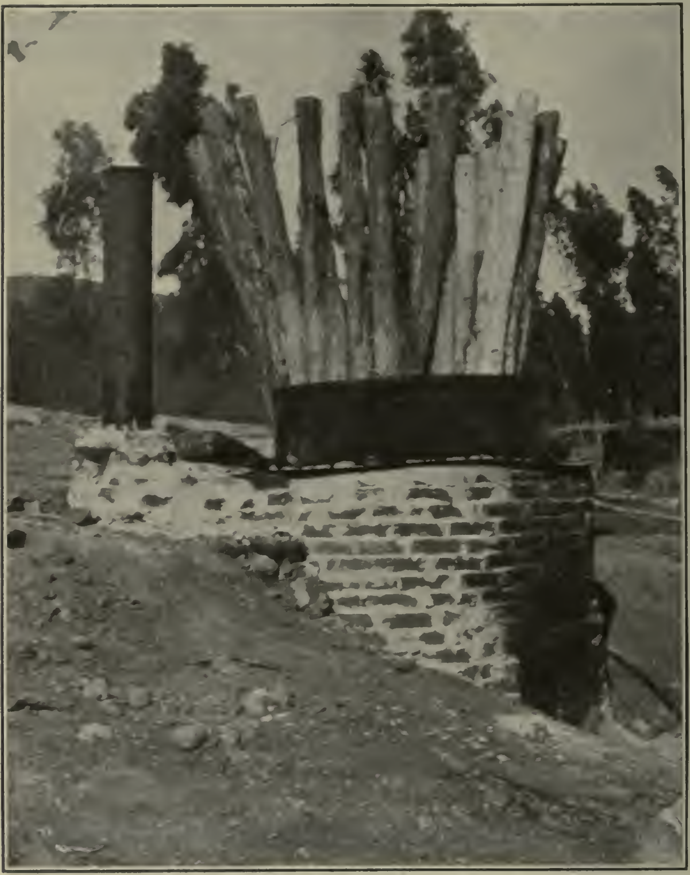

FIG. 14.—Heavy iron tank with brick fire box.

It may prove of advantage sometimes for a number of farmers to cooperate in the erection of a permanent plant of this kind or a portable plant, such as that shown in figure 16. Such a plant could either be loaned to each of the cooperators in turn to treat his own timber or it could be placed in charge of an operating crew of two or three men who would make all the treatments.

COLD-BATH OR SOAKING TREATMENT.

In the cold-bath process the wood is treated by soaking for long periods in a tank of preservative at ordinary air temperature. This method of treatment has not been thoroughly investigated, but it is probable that but few woods can be successfully impregnated in this way with oils, since cold oils do not penetrate wood readily. Water solutions like zinc chloride would probably penetrate somewhat more readily. In any case it would be necessary to have the wood particularly well seasoned.

THE DIPPING PROCESS.

The dipping process is considered suitable only for preservatives of an oily nature. The wood is simply heated in oil at from 200° to 220° F. for from 5 to 15 minutes, or longer. This allows all checks and defects to become filled with oil, but the penetration and absorption of oil are usually slight. On account of the small amount of oil used and the large number of posts that can be treated in a day, it is much cheaper than open-tank treatment, but it is also much less effective. Under no circumstances should any but thoroughly peeled, well-seasoned timber be used. Unseasoned wood, or that which is wet with snow or rain, is not suitable because the oil will not penetrate it readily. In very cold weather a longer time in the hot oil will be required to get the wood warm. The treatment should extend at least 6 inches above the ground line.

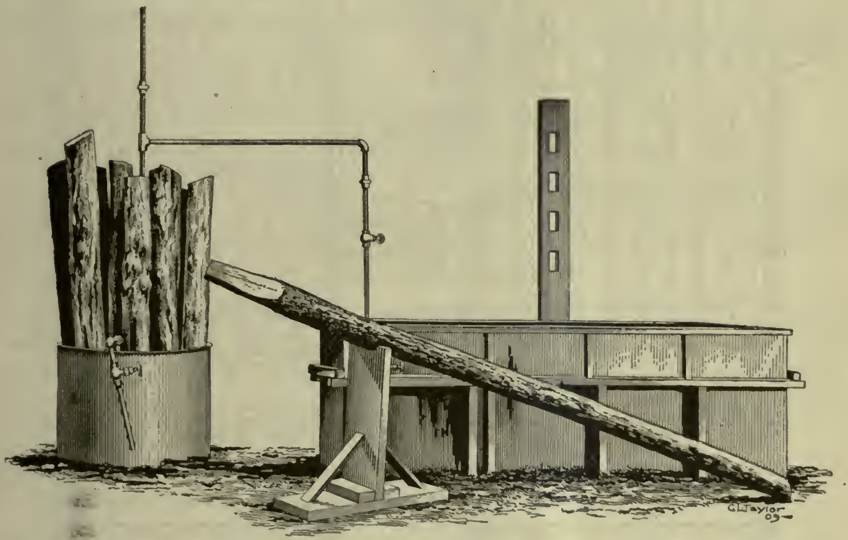

FIG. 15.—Experimental outfit heated by steam. The rectangular horizontal tank is for the cold bath.

Dipping is more suitable for protecting the sapwood of comparatively durable posts than for nondurable posts. It may add from

1 to 3 or 4 years to the life of a durable post which ordinarily would last 8 or 10 years untreated. This is well worth the cost of the treatment. An addition of three or four years to the life of a nondurable

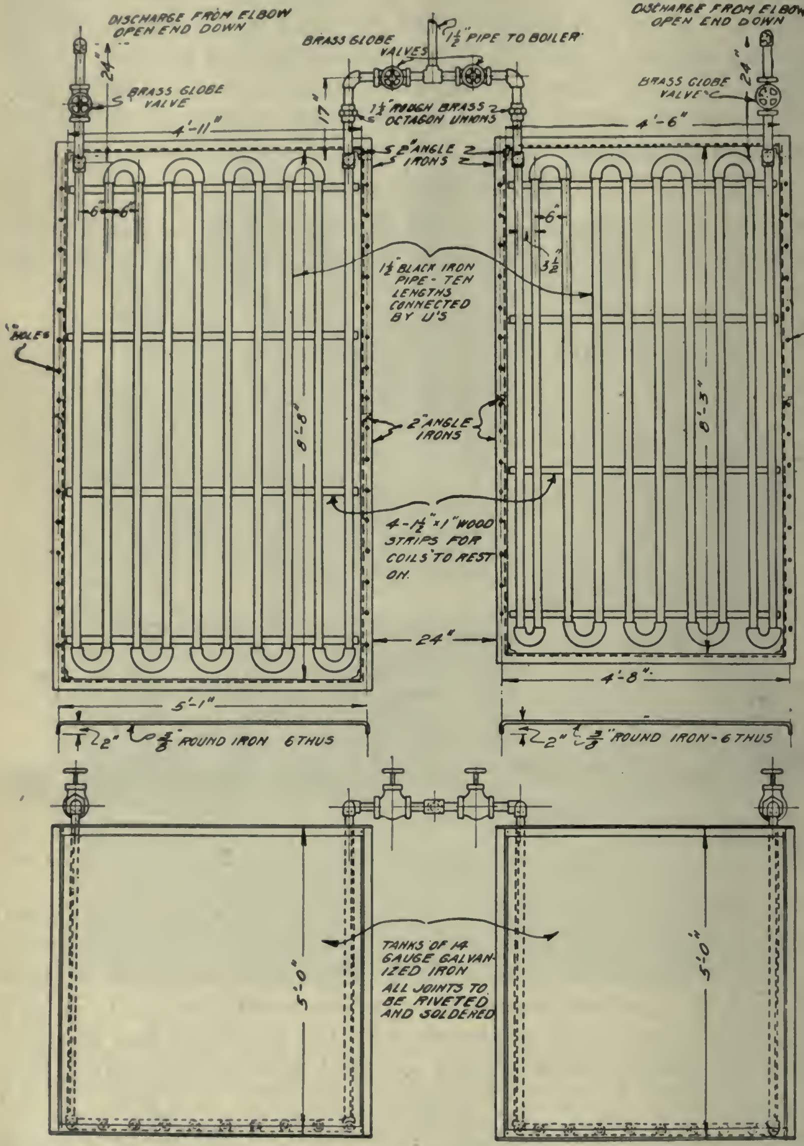
DISCHARGE FROM ELBOW OPEN END DOWN
24"
BRASS GLOBE VALVE
BRASS GLOBE VALVES
1½" PIPE TO BOILER
DISCHARGE FROM ELBOW OPEN END DOWN
BRASS GLOBE VALVE
24"
17"
1½" ROUGH BRASS OCTAGON UNIONS
4'-11"
4'-6"
2" ANGLE IRONS
6"
6"
6"
3½"
1½" BLACK IRON PIPE - TEN LENGTHS CONNECTED BY U'S
HOLES
15'
8'-8"
2" ANGLE IRONS
8'-3"
4-1½"×1" WOOD STRIPS FOR COILS TO REST ON.
24"
4'-8"
5'-1"
2"
⅜" ROUND IRON 6 THUS
2"
⅜" ROUND IRON - 6 THUS
TANKS OF 14 GAUGE GALVANIZED IRON
ALL JOINTS TO BE RIVETED AND SOLDERED
5'-0"
5'-0"

FIG. 16.—Details of construction of tanks for portable plant.

post which would last only two or three years untreated would increase the value of the post more than enough to pay for the treatment, but it would still have a comparatively short life. If possible, nondurable species should be given a better treatment, such as the open-tank or pressure treatment.

The apparatus for dipping consists of a tank, a thermometer, and some means of heating. Generally, it will be advisable to use a comparatively small tank in order that there will not be a large amount of oil left over after the last posts have been treated.

BRUSH TREATMENT OR PAINTING.

Brush treatment or painting is also considered suitable for oils only and consists in applying two coats of not preservative to the wood. The oil should be heated to from 200° to 220° F. and flooded over the wood rather than painted upon it. Especial care should be taken to fill every check and defect in the wood, and the first coat should be allowed to dry completely before the second coat is applied. The advantage of the painting method over the others is the small amount of preservative it requires and its cheapness and simplicity. No excess of preservative need be left over after the last post is treated. It is also of value in treating portions of large sticks which can not readily be dipped or open-tank treated, and in treating timber at joints and all points of contact where decay is liable to occur. Its disadvantage is that it usually adds less to the durability than dipping, open-tank, or pressure treatment.

Like dipping, the painting method is most suitable for use on peeled, thoroughly seasoned, and dry timber. It is best to use it in warm weather; for in cold weather, when the hot creosote touches the cold wood, it immediately cools and does not penetrate readily. Both treatments are more suitable for protecting the sapwood of durable posts than for very nondurable posts.

The apparatus for brush treatment consists of a large kettle or pail of some kind to heat the oil in, a smaller pail to paint from, and a wire-bound, long-handled paint brush. An old broom might be substituted for the paint brush if desired. If a thermometer is available, it can be used to advantage. If none can be had, the oil should be heated very hot but not to boiling. Care should be exercised to prevent the oil from boiling over and taking fire.

Ordinarily the oil is heated over an open fire; but in cases where a large amount of work is to be done, or the work is widely distributed, it may be found advantageous to use a special oil heater, such as is shown in figure 17. The heat is supplied by a gasoline blow torch, and a thermometer is used to regulate the temperature. The pail is made detachable, so that one or more can be in use while another is heating. The construction of the heater is simple, and it can be made by any competent tinner.

CARE OF TIMBER AFTER TREATMENT.

The effectiveness of any of the methods of treatment which have been described is dependent upon keeping an unbroken layer of treated wood over the entire treated surface.

Care should be exercised in handling treated timber to see that the treated wood is not scraped away and untreated wood exposed. If such an accident does occur the exposed untreated wood should be given two or three coats of hot creosote.

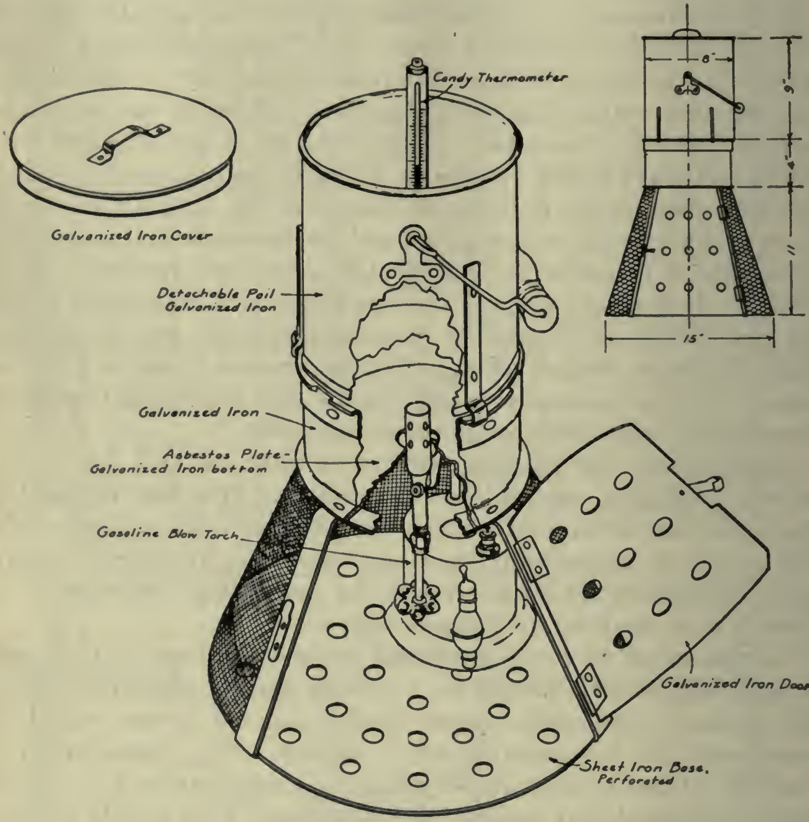

FIG. 17.—Creosote heater for brush treating.

Treated timber should never be cut if it can be avoided. All sawing and framing should be done, if possible, before treatment. If it is necessary to saw after treatment, the exposed untreated wood should be painted with creosote before it is put in place.

If butt-treated posts or other timbers of which only a part is treated are not to be used for some time, they should be open piled after treatment. If they are close piled or allowed to lie on the ground for a considerable length of time, decay is likely to start in the untreated parts. If the timber is treated all over, it should be close piled, but the pile should be raised off the ground.

In setting treated posts, poles, etc., great care should be used to avoid setting them too deep. At least 6 inches of treated wood, and more if convenient, should extend above the ground after the posts are set. In a number of cases where this precaution has not been observed the posts have decayed above the treated part.

ADAPTABILITY TO TREATMENT.

As is shown in Table 1, some species of wood are much easier to treat than others; and whenever there is a choice between several species this fact should be taken into consideration.

In general, the pines are very easy to treat. Other woods which have been found to treat very readily in the form of round posts are beech, river birch, gum, pin oak, red oak, and sycamore. Many other species, however, can be successfully treated; and, in fact, almost any kind of nondurable wood can be improved by proper treatment. Treatment will also greatly improve many of the species having durable heartwood and nondurable sapwood.

In most woods the sapwood treats much more easily than the heartwood. In very few species can a satisfactory penetration be obtained in the heartwood by the open-tank process. In general, therefore, a more uniform and satisfactory treatment can be obtained in round posts, of which the entire outer surface is sapwood, than in split or sawed posts, in which heartwood is necessarily exposed. Among the exceptions to this rule are hemlock, in which the sapwood is as difficult to penetrate as the heartwood, and sycamore, in which the heartwood is readily treated.

In some localities there are considerable amounts of standing dead timber which has been killed by fire, insects, or some tree disease, and which is still sound. For the most part this timber can be successfully treated. Such timber, if it is entirely free from decay and not seriously injured by wood borers, is practically as good as live timber and is well adapted to treatment because already more or less seasoned. It makes good material for posts, poles, and many other of the common forms in which wood is used. Blight-killed chestnut and fire and insect killed lodgepole pine are in this class.

COST OF TREATMENT.

As a rule, the principal item of cost in the treatment of timber is the preservative. The price of creosote varies. Near the manufacturing plants it can usually be obtained at from 20 to 35 cents per gallon in small lots. In other localities the freight will make the price somewhat higher. In tank-car lots the price ranges from 10 to 25 cents per gallon. It may prove feasible in some cases for a number of farmers to cooperate in buying creosote in order to obtain the reduction in price due to purchasing in larger quantities. The exact cost in any case will have to be determined by inquiring of the dealer from whom the oil is to be obtained.

The cost of applying the preservative depends mainly upon the number of posts to be treated, the cost of apparatus, labor, and fuel, and the number of posts which can be treated per day. The number of posts treated per day will, of course, vary according to their size and ease of treatment, the size of the plant, etc. Fuel and labor charges are sometimes ignored in fence-post treatment, and the number of posts treated per day is then not quite so important. The cost of treatment will vary greatly in different localities, and in accordance with differing local conditions, so that a general cost figure can not be given. In Table 2, however, are given some figures obtained in the open-tank treatment of posts in several localities. The cost of oil may now be somewhat greater than that given in the table. The cost of the apparatus is not included in the calculations.

TABLE 2.—*Cost of treatment under certain conditions.*

Locality.	Kind of post.	Cost of oil.		Cost of treating.	Total cost of treating.	Remarks.
		Per gallon.	Per post.			
Louisiana	Loblolly pine	$0.15	$0.09	$0.01	$0.10	Entire post impregnated, cost of labor not included.
Maryland	Scrub pine	.15	.09	.01	.10	Do.
Maine	Quaking aspen	.12	.06	.01	.07	Butt impregnated, top dipped, cost of labor not included.
Minnesota	Cottonwood	.12	.06	.01	.07	Do.
California	Western yellow pine.	.24	.12	.07	.19	Butt impregnated; cost of labor included at $2.50 per day.

VALUE OF TREATMENT.

Unless a reasonable saving can be effected by preservative treatment of wood, the expense involved is not justified. The saving due to preservative treatment will depend upon local conditions. In some localities durable posts are expensive and difficult to obtain; while nondurable, easily treated woods are abundant and cheap. It is in such localities that treatment is particularly desirable. In other localities there may be a plentiful supply of durable timber which can be obtained very cheaply. In such places it may not be advisable to attempt preservative treatment.

The chief points which must be considered in determining whether treatment will pay are the comparative cost and average life of untreated and treated posts. The cost and approximate life of untreated posts of the different species in common use in any locality will generally be known to the residents of that locality. It is estimated that a thorough open-tank treatment of fence posts, for example, a heavy butt treatment and a light top treatment, will give even to nondurable woods an average life of at least 20 years. This estimate is based on the best information obtainable on the durability of creosoted posts and other creosoted timber. It can not be considered as conclusive, however.

In estimating the cost of an open-tank treated post the chief items to be considered are the original cost of the post and the cost of the oil absorbed. In general, from four-tenths to six-tenths of a gallon of creosote will be required per post. The cost of labor may or may not be included, according to the individual circumstances. In order to get a close estimate of the annual charge, the cost of setting the post and interest on the investment are sometimes included in the calculations.

If it is found in a certain locality that cedar posts which will last 12 years can be obtained for 30 cents and that treated pine which will last 20 years can be obtained for the same price, money will be saved by using the treated pine; or, if a locust post can be obtained for 35 cents and a treated beech post which will probably last about as long costs half as much, it will be economical to treat the beech. On the other hand, if an untreated post which will last 12 years can be obtained for 10 cents and a treated post which may be expected to last 20 years costs 30 cents, it will not be economy to treat.

SERVICE TESTS OF TREATED POSTS.

To obtain more exact information about the average life of treated posts under various conditions, experimental posts are being tested in fences in many parts of the country and careful records of their durability are being kept. In Table 3 are given the results so far obtained in a number of these experiments.

TABLE 3.—*Results so far obtained in experiments on durability of creosoted posts.*

Location.	Kind of posts.	Treatment.	Date set.	Date of last inspection.	Years' service at last inspection.	Number in test.	Number removed up to last inspection.[a]	Per cent removed up to last inspection.[a]	Remarks.
Ames, Iowa	White cedar	Open tank	1909 and 1910	June, 1915.	5 and 6	522	0	0	
Do	Black walnut	do	Spring, 1909	do	6	50	0	0	
Do	Willow	do	Fall, 1909	do	5½	45	0	0	About one-third of these in bad condition, in tops, although not removed.
Zumbra Heights, Minn	Basswood	Entire post	Winter, 1908	June, 1913.	4½	481	3	0.6	
Do	Red oak	do	do	do	4½	254	1	0.4	
Do	do	Open tank, butts only.	do	do	4½	59	0	0	
Auburn, Ala	Loblolly pine	Open tank, entire post.	Summer, 1910	Jan., 1915	6½	55	0	0	Left in pile 2½ years; in ground 4 years.
Calhoun, La	do	do	1908 to 1910	do	5 to 7	395	8	2	Left in pile various periods up to 2½ years; in ground 4½ to 6½ years.
Do	Bay	do	1908 to 1910	do	5 to 7	145	27	19	Do.
Do	Cypress	do	do	do	5 to 7	70	1	2	Do.
Do	Sweet gum	do	do	do	5 to 7	177	2	1.0	Do.
Do	Tupelo gum	do	do	do	5 to 7	81	4	5.0	Do.
College Park, Md	White oak	do	1909	Nov., 1914	5	51	0	0	
Do	Black gum	do	do	do	5	49	0	0	
Do	Yellow poplar	do	do	do	5	51	0	0	1 missing.
Do	Scrub pine	do	do	do	5	101	0	0	
Do	Willow	do	do	do	5	103	0	0	
Do	Maple	do	do	do	5	50	0	0	3 missing.
Do	Sycamore	do	do	do	5	52	0	0	
Do	Beech	do	do	do	5	51	0	0	
Do	Chestnut	do	do	do	5	50	0	0	
Do	Birch	do	do	do	5	50	0	0	
Do	Red juniper	do	do	do	5	45	0	0	
Clemson College, S. C	Loblolly pine	do	Jan. to Aug., 1909	Jan., 1915	5½ to 6	279	37	13.2	
Do	Yellow pine	do	do	do	5½ to 6	167	15	9.0	
Do	Post oak	do	do	do	5½ to 6	71	10	14	

[a] A few posts show more or less decay, but since they were not removed at the time of the last inspection they are not recorded in these columns.

PROLONGING THE LIFE OF OTHER FORMS OF FARM TIMBERS.

There are many forms of timber used on the farm to which treatment can be advantageously applied. Among these are silos, rural telephone poles, shingles, greenhouse boards, sills, foundation timbers, bridge timbers, board walks, wooden gates, windmill frames, porch columns, well curbing, etc. The treatment of any nondurable wood which is used where conditions are favorable to decay is worthy of careful consideration.

SILOS.

A thorough treatment with coal-tar creosote will make a wooden silo more resistant to decay and less subject to shrinking and swelling. It will also make painting unnecessary.

The most satisfactory way to inject creosote into silo staves is by impregnation under pressure. It may sometimes be possible for a farmer to haul his untreated silo to a creosoting plant and have it treated, but pressure treatments will usually have to be made by the manufacturer before the silo is sold. Some manufacturers are already doing this, and it is now possible to purchase a pressure-treated silo all ready to set up.

Next to pressure treatment, open-tank treatment is best; but on account of the length of the staves and the long, narrow tank required it may be inconvenient to use this method. A good combination treatment would be to give the lower 2 or 3 feet of each stave an open-tank treatment and the remainder a two-coat brush treatment. If this is done, the part of the staves most subject to decay will receive the heaviest treatment. All the wood which touches the foundation should be thoroughly treated. As with any treated timber, no sawing or cutting that can be prevented should be done after the wood is treated. All untreated surfaces necessarily exposed by cutting should be heavily painted with the preservative.

Brush and dipping treatments are less efficient than open-tank or pressure treatments and will not give as great an increase in durability. They may be used to advantage, however, when the better methods are entirely out of the question.

One possible objection to the use of creosoted lumber in silos is that the silage might be contaminated by creosote bleeding from the wood. Information obtained by the Forest Service, however, indicates that there is little danger of this if proper care is used. In order to prevent contamination, the treated wood should be thoroughly air seasoned in open piles after it is treated and before it is put into the silo. In the case of open-tank or pressure treatments, the absorption of oil should not exceed 8 or 10 pounds per cubic foot.

Of the woods in general use for silo construction, the pines are, as a class, the most easily treated; hemlock, tamarack, spruce, and Douglas fir are somewhat more difficult. With pressure treatment the greatest saving can usually be effected by using the cheaper woods, as the difference in the durability of the various species is less after treatment than before. It is questionable if the treatment of such durable species as heart redwood and heart cypress would pay.

SHINGLES.

The application of paint is the preservative measure most commonly used for shingles; and, if the paint is properly applied, it will add to their durability by protecting them from the weather, keeping out moisture, and preventing cupping. If it is not properly applied, however, it may even hasten decay. From a preservative standpoint, the best way to apply the paint is by dipping the shingles in it. This may be found impracticable, however, since the amount of paint which would adhere to the shingles would in many cases be too great unless some means were provided to brush off the excess.

When the shingles are painted after the roof is laid, a ridge of paint is liable to form at the base of each shingle. This tends to hold the water after a rain and keep the shingles moist, thus making conditions more favorable to decay.

Brush treatment with creosote or a good shingle stain does not leave a ridge like ordinary paint and can be recommended as good practice, but dipping the shingles in the preservative is better in this case also. The best results in preventing decay are obtained, however, by first heating and then cooling the wood in the preservative, as described for the treatment of fence posts.

The open-tank process has already been explained. The apparatus used for posts may be employed; or if shingles exclusively are to be treated, the form of the outfit may be modified. The simplest apparatus is a single tank large enough to hold a bundle of shingles. If a larger capacity is desired, the depth rather than the width should be increased; for, in order to minimize the loss of oil by evaporation, the oil surface exposed to the air should be kept as small as possible. The best treatment for various kinds of shingles has not yet been determined. The most desirable treatment is the one which gives the best penetration with the least absorption of oil. Sap-pine shingles, thoroughly seasoned, can be completely penetrated without difficulty, but cedar shingles are more difficult to treat. The proper treatment in any case must be determined by observing the absorption of oil and the penetration secured and varying the treatment accordingly. The oil should not be allowed to get too hot, however, or the shingles held in it for too long a time; for in either of these events the shingles may become somewhat brittle.

While creosote treatment can be expected to increase very materially the resistance of shingles to decay, the treated shingles possess certain objectionable qualities which should be kept in mind when considering their use; for instance, their strong odor and their contamination of cistern water. Further, since the shingle nails become covered with creosote and can not be held in the workman's mouth, it is said to be more difficult to lay these shingles. The odor, however, disappears in the course of a few weeks—2 weeks in one case observed. The contamination of the cistern water may be of longer duration, though in one instance the water was tasteless after 3 days of rain. All these objections may be lessened if the shingles are seasoned for a few weeks between treating and laying.

It is held by some that creosote treatment makes shingles more inflammable and thus increases the fire danger, and it seems probable that this is true to a cerain extent. It is a point, however, which has never been satisfactorily settled.

TELEPHONE POLES.

When farmers' cooperative telephone lines are constructed, the treatment of the poles will frequently effect a saving in the cost of upkeep. The open-tank treatment will, of course, give a much longer life than brush treatment; but the cost of the tanks, the extra oil required, apparatus for handling the poles, and the extra labor may not be justified unless a large number are to be treated. Brush treatment will, therefore, in many cases be the most practicable method to use. For the reasons given in the discussion of the dipping and brush treatment of posts, however, brush treatment of poles is most suitable for treating the sapwood of durable species. Poles of nondurable species should, if at all possible, be given a better treatment, such as open-tank, or even pressure treatment. In most parts of the United States a butt treatment is sufficient to protect the poles; but in the warm, moist climate of the southern States it is necessary to treat the entire pole, especially if sap pine or other nondurable woods are used.

The tops of the poles and the gains cut in the poles to hold the cross-arms should be brush treated. Pole braces should be treated like the poles. Wherever a pole brace touches a pole, both should be brush treated at the point of contact.

BRIDGE TIMBERS.

Treatment of the timbers and planks of permanent bridges will add materially to their resistance to decay. Open tank and pressure treatments are the best. Brush or dipping treatments of the face of the planks would soon be worn away and would be of little value; but they may be used to advantage in other parts of the structure.

SILLS AND FOUNDATION TIMBERS.

Sills and foundation timbers in contact with the ground or with stone or concrete foundations frequently decay rapidly, and preservative treatment is advisable. It is probable that brush treatment will usually be found the only convenient way to treat such timbers on account of their size, but wherever possible better treatments should be used.

LUMBER USED IN GREENHOUSES.

Lumber used in greenhouses is usually subject to rapid decay, which can be greatly retarded by preservative treatment. If creosoted boards are used close to steam pipes, however, some of the oil is volatilized by the heat, and the fumes have a bad effect on the plants. In other parts of the greenhouse, where the boards are not exposed to heat, the creosote has been found to have no bad effect on the plants. It is desirable in all cases to air season the boards thoroughly after treatment before putting them in service, in order to prevent the possibility of creosote bleeding from them after they are installed. Creosotes containing comparatively large amounts of low-boiling oils are not as suitable for greenhouse timbers as the oils of higher specific gravity, because they are much more volatile.

JOINTS AND POINTS OF CONTACT.

Experience has shown that in any timber structure where the wood comes in contact with wood, stone, or other material decay is liable to occur more rapidly at the point of contact than in other parts of the structure. If it is impracticable to treat the timber for the whole structure, it will frequently be profitable to give a good brush treatment to the joints and other points where decay is usually most severe.

CONCLUSION.

In every locality the question of preservative treatment of farm timbers should be given careful consideration. It is often difficult for a farmer to treat his own material efficiently. This, however, does not indicate that the work should be neglected, but only that some other means of securing the desired result should be sought. There are two practical methods of doing this. One is for some individual to undertake the work for the neighborhood. In many cases a small wood-preserving plant could be profitably operated in connection with a threshing outfit, a feed mill, or sawmill. The other plan is for several individuals to cooperate in establishing and operating a plant. The means may vary, but it can not be too strongly emphasized that every agricultural district should possess the facilities for increasing the durability of farm timbers by preservative treatment.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 745 AUGUST 15, 1916

OFFICE OF THE SECRETARY.

Contribution from the Office of Farm Management, W. J. Spillman, Chief.

WASTE LAND AND WASTED LAND ON FARMS.

By JAMES S. BALL, *Assistant in Farm Accounting.*

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On the average American farm there are certain waste areas of land. Some of these can be brought under the plow by using proper methods and a sufficient outlay of capital, but others can not be made tillable by any reasonable expenditure of effort or money. Of the latter, certain areas may be made productive by pasturing or giving them over to the production of timber. Many waste areas, however, owing to natural conditions, can never be profitably reclaimed, no matter how efficiently the land may be managed.

Certain other areas, found on almost all farms, may be termed wasted areas. That is, they are misused in such fashion that they produce nothing that adds to the farm income. These two classes of waste and wasted land, not being productive of income, may be classed as nonproductive farm land.

An important question to one who is considering leasing or buying a farm, is, what proportion of the land is nonproductive? And this question is almost equally important to the man who owns or operates a farm. In the latter case the question might better take this form: What per cent of my land is adding nothing to my income? On farms where land is cheap this is not a vital consideration, as the interest on the capital invested in the nonproductive portion of the farm land is not great; but as lands become higher in price it becomes more necessary to study efficiency in the use of farm land in order to avoid the loss entailed by having much capital invested in nonproductive land.

EFFICIENCY IN UTILIZATION OF LAND.

Investigations made by the Office of Farm Management,[1] as well as those made by certain State experiment stations,[2] have developed the fact that of the three more important elements of successful farming, the first and most important is the size of the business. A recognized authority on successful farm management [3] has written: "The area in crops and the natural yielding power of the soil are the most important factors in determining profits on farms."

Efficient utilization of farm land means a high percentage of productive area, thus increasing the income-producing part of the farm to the utmost. It logically follows that an important factor in determining the fair acre value of a farm is the answer to the question: What proportion of the total area can be made productive? This point of view is of great significance in studying the respective economic values of different farms. For instance, compare a farm of 100 acres at $200 per acre, having 95 acres in shape to yield available products, with another of the same acreage at $150 per acre, having 65 acres productive. All other features of these two farms being similar, the former should prove more profitable, as the productive land thereon costs but $210 per acre as against $230 per acre on the "cheaper" farm. Table I shows the cost per acre of the productive land on 100-acre farms costing $100 per acre, with various percentages of the land available for productive purposes. It is not always the farm that costs the least per acre that is the most economical to buy or operate.

Reclamation of nonproductive land, in so far as it is possible and profitable, is a very important point of farm economy. The resultant increase in value is due not only to increased productiveness, but also to improvement in the appearance of the place. The latter factor is often of sufficient importance fully to warrant the expenditure of time and money in clearing up the waste places and making them productive, in so far as is economically possible.

TABLE I.—*Relation between percentage of land available for production and cost per acre.*

(Value of land, $100 per acre.)

Percentage of land available for production.	Cost per acre of available land.	Percentage of land available for production.	Cost per acre of available land.
100	$100.00	50	$200.00
90	111.11	40	250.00
80	125.00	30	333.33
70	142.86	20	500.00
60	166.67	10	1,000.00

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[1] See U. S. Dept. Agr. Bulletins 41 and 117, by E. H. Thomson and H. M. Dixon, entitled, respectively, "A Farm Management Survey of Three Representative Areas in Indiana, Illinois, and Iowa," and "Profits in Farming on Irrigated Areas in Utah Lake Valley."

[2] See Cornell Experiment Station, N. Y., Bulletins 295 and 349, entitled, respectively, "An Agricultural Survey," by G. F. Warren and K. C. Livermore, and "Some Important Factors for Success in General Farming and in Dairy Farming," by G. F. Warren.

[3] Warren, G. H., "Farm Management," p. 518.

PRODUCTIVE AND NONPRODUCTIVE LAND.

Broadly speaking, productive farm land is that used for:

The production of crops.

The economic pasturing of animals.

Woodland yielding marketable timber or firewood, maple sugar, or other salable forest products.

Nonproductive farm areas may be roughly classified as follows:

Wasted..	Land unnecessarily taken up by farm buildings and lots. Land taken up by unnecessary lanes and roads. The part of any public road included in a farm area. Land occupied unnecessarily by fence rows, open ditches, headlands, or turning spaces bordering fields and terraces.
Waste...	Land rendered untillable by swamps, rocks, large rocks, and ledges, ravines, steep slopes, sloughs, streams, etc. Woodland not yielding salable products. Uneconomic pasture land.

While, literally speaking, all land necessarily occupied by farm buildings, fences, etc., is nonproductive, such occupation is necessary to the development of the productivity of the rest of the farm; hence, for the practical purposes of this discussion, "nonproductive land" will be taken to mean only such land as is either left untilled by inefficient management or is not susceptible of profitable improvement. The total amount of land taken out of the farm total by these nonproductive areas is in many cases a large proportion of the whole. Such waste or wasted areas should be carefully considered by the prospective buyer of a farm.

Table II shows the average percentages of improved land on farms in the States and divisions of the United States. The difference between improved land and productive land should be noted in this connection, as the terms are not wholly synonymous. Unimproved land, such as good timber land, sugar groves, etc., may be productive; while improved land, such as is occupied by the farm buildings, fences, and roads, may produce nothing.

There are other causes of nonproductivity, such as large areas of alkali, little or no rainfall, etc., but these causes affect whole regions rather than parts of individual farms and do not come within the scope of this publication.

TABLE II.—*Percentage of farm land improved, by divisions and States, Census of 1910.*

Division and State.	Improved land.	Division and State.	Improved land.
	Per cent.		*Per cent.*
UNITED STATES	54.4	Mountain	26.7
		Pacific	42.9
New England	36.8	The North	70.1
Middle Atlantic	67.9	The South	42.5
East North Central	75.4	The West	34.2
West North Central	70.6		
South Atlantic	46.7	East of the Mississippi	59.5
East South Central	53.9	West of the Mississippi	50.8
West South Central	34.4		

TABLE II.—*Percentage of farm land improved, by divisions and States, census of 1910*—Continued.

Division and State.	Improved land.	Division and State.	Improved land.
New England:	*Per cent.*	South Atlantic—Continued.	*Per cent.*
Maine	37.5	West Virginia	55.1
New Hampshire	28.6	North Carolina	39.3
Vermont	35.0	South Carolina	45.1
Massachusetts	40.5	Georgia	45.6
Rhode Island	40.2	Florida	34.4
Connecticut	45.2	East South Central:	
Middle Atlantic:		Kentucky	64.7
New York	67.4	Tennessee	54.3
New Jersey	70.1	Alabama	46.8
Pennsylvania	68.2	Mississippi	48.5
East North Central:		West South Central:	
Ohio	79.8	Arkansas	46.4
Indiana	79.5	Louisiana	50.5
Illinois	86.2	Oklahoma	60.8
Michigan	67.8	Texas	24.3
Wisconsin	56.5	Mountain:	
West North Central:		Montana	26.9
Minnesota	71.0	Idaho	52.6
Iowa	86.9	Wyoming	14.7
Missouri	71.1	Colorado	31.8
North Dakota	72.0	New Mexico	13.0
South Dakota	60.8	Arizona	28.1
Nebraska	63.1	Utah	40.3
Kansas	68.9	Nevada	27.7
South Atlantic:		Pacific:	
Delaware	68.7	Washington	54.4
Maryland	66.3	Oregon	36.6
District of Columbia	84.7	California	40.8
Virginia	50.6		

THE FARMSTEAD.

The group of farm buildings and adjoining lots and yards, together with the home orchard and garden, constitute what is commonly called the farmstead. Every farm must give up to this purpose more or less land. The size of this necessary area will vary with the size and type of farm, climate, and individual tastes of the owner. Some authorities advise that ample space be allowed for the farmstead, and this is doubtless good advice, provided the owner is able to afford it. It should always be remembered that, excepting the orchard and garden, every acre of land over actual necessity devoted to this purpose reduces the productivity of the farm by the net amount an acre will produce. Within certain limits, however, land well utilized for the setting of a home has a value to the farm family that can not be measured in crop yields per acre.

The two farmsteads shown by maps in fig. 1 illustrate an extended and a compact arrangement of farm buildings. These two farms do not differ greatly in area, and have about the same gross income.

The one farmstead has an "ample" layout and occupies over three acres of good land, or over 1 per cent of the total farm area. The other, under a "compact" layout, where all the necessary farm buildings except the dwelling have been brought together under one roof covering a large two-story and basement barn, uses one acre of land, or less than ½ per cent of the total area.

It is not intended to recommend that all should pattern after the farmstead layout as shown in the right half of fig. 1. The two layouts are shown merely to bring out the two extremes. Most people would prefer something approaching a happy medium between the two.

THE FARM LANES AND ROADS.

Very few farms will be found without interior roads or lanes. These are sometimes necessary to give access to the various fields, as well as to permit the passing of animals to and from pasture, often located in the rear portion of the farm. For the latter purpose wide lanes are often used which, being kept in sod, are substantially elongations of the pasture. These wide lanes are usually uneconomic for the reason that they are customarily located on good arable land, while the areas to which they lead are often the least valuable portions of the farm, useful only as pasture.

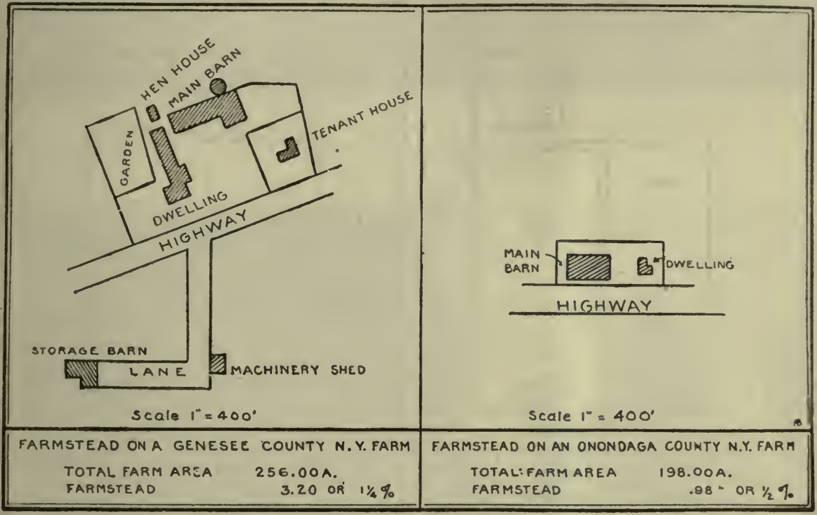

FIG. 1.—Two ordinarily undesirable extremes in farmstead arrangement.

Under certain circumstances farm lanes are unavoidable, but often a little thought and a slight rearrangement of the farm organization plan will eliminate them. Fig. 2 shows two maps of the same farm in Monroe County, N. Y., before and after the only farm lane was dispensed with. In this case the reorganization was effected by the simple expedient of staking out the two cows upon which the family depended for its milk supply. The new arrangement is found considerably more efficient than the old, as a large part of the area formerly occupied by the lane now produces crops, and two uneconomic fence lines, entailing an annual upkeep expense, have been eliminated. (See also fig. 9.)

THE PUBLIC HIGHWAY.

Not infrequently a part of the area of the public highway touching the farm is included in the total farm area. This is a fixed practice in certain regions. Sometimes under exceptional circumstances it is possible to raise crops on the greater part of the public highway area by tilling the strip between the actual roadway and the right-of-way line, or it may be seeded to grass and pastured. (See figs. 3 and 4.) In determining the value of a farm, consideration should be taken of the area of highways included in the acreage, so that the farm can be judged by its actual available area and not by that called for by the deed measurements.

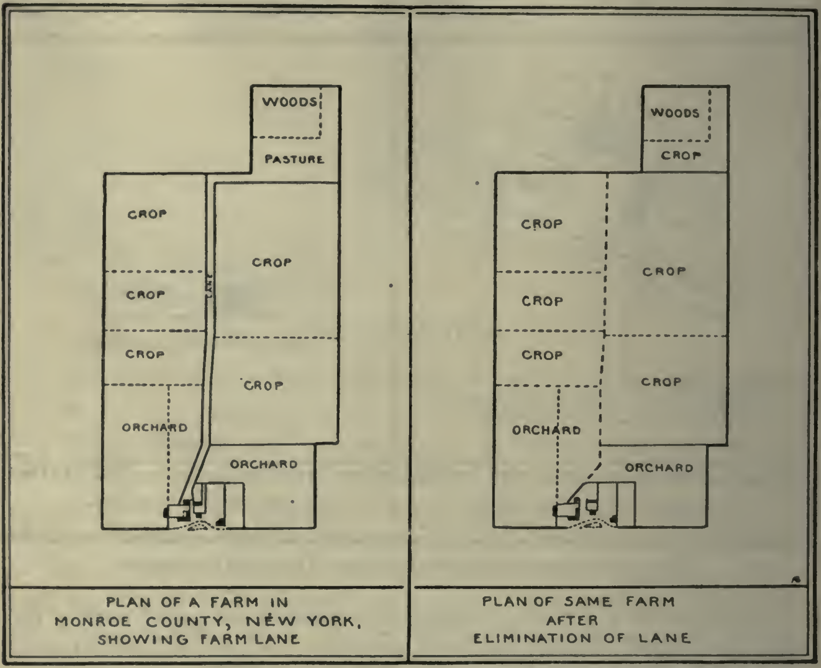
WOODS
PASTURE
CROP
CROP
CROP
CROP
CROP
ORCHARD
ORCHARD
PLAN OF A FARM IN MONROE COUNTY, NEW YORK, SHOWING FARM LANE
WOODS
CROP
CROP
CROP
CROP
CROP
CROP
ORCHARD
ORCHARD
PLAN OF SAME FARM AFTER ELIMINATION OF LANE

FIG. 2.—Comparison of farm arrangement before and after elimination of a central lane by discontinuing back pasture.

UNTILLABLE AREAS.

Many areas found on farms are permanently untillable by reason of the presence of rocky ledges, steep slopes, deep ravines, wide stream areas, or undrainable swamps. (See fig. 5.) Permanently untillable areas can be made productive by pasturage if they will grow enough grass to make it economy to pasture them, or they can sometimes be given over to the production of timber.[1]

Other areas, broken by stumps, brush, large bowlders, gullies, swales, etc., which it is possible to reclaim by a resort to the proper

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[1] See bulletin 295, Cornell experiment station, N. Y., pp. 464–473.

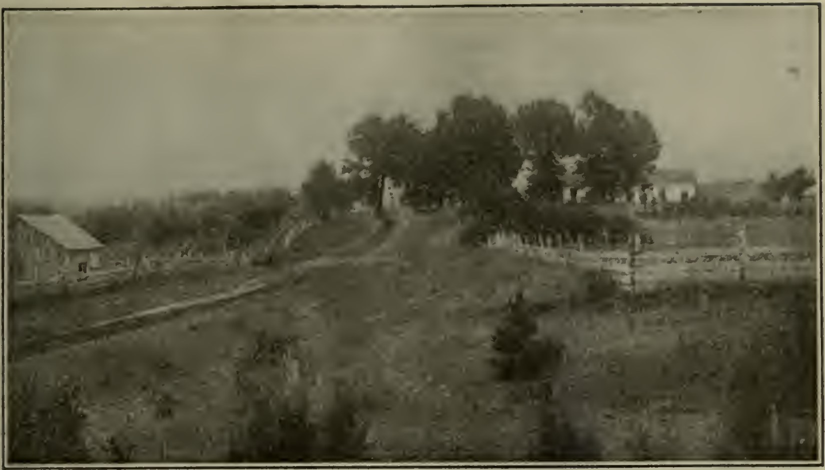

FIG. 3.—Land wasted by the wayside. By cultivating to the actual right-of-way line several acres of nonproductive land might be reclaimed.

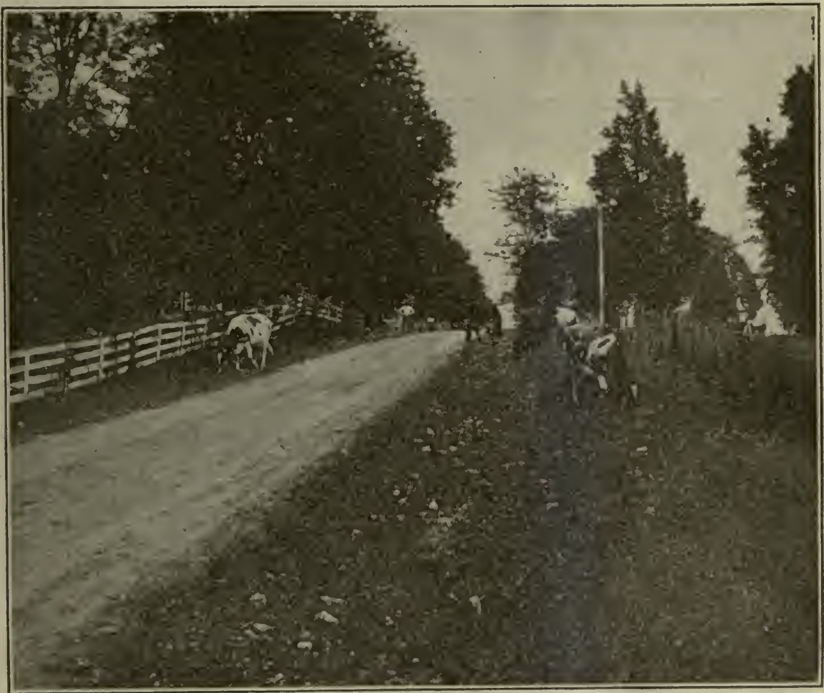

FIG. 4.—Getting the most out of the part of the farm included in the highway. One way of making it partly productive agriculturally.

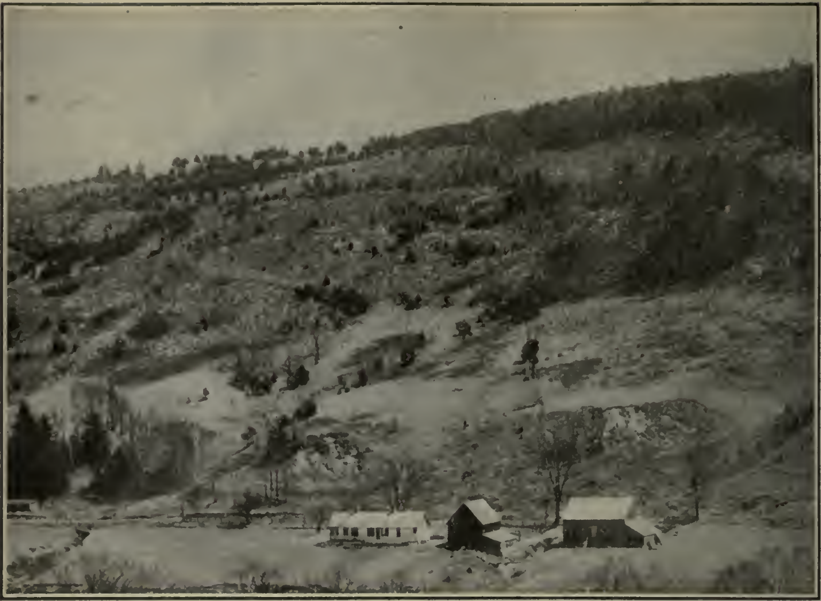

FIG. 5.—A steep, rocky slope, untillable and not economically pasturable. The more acres of this kind on a farm the harder it is to make a profit.

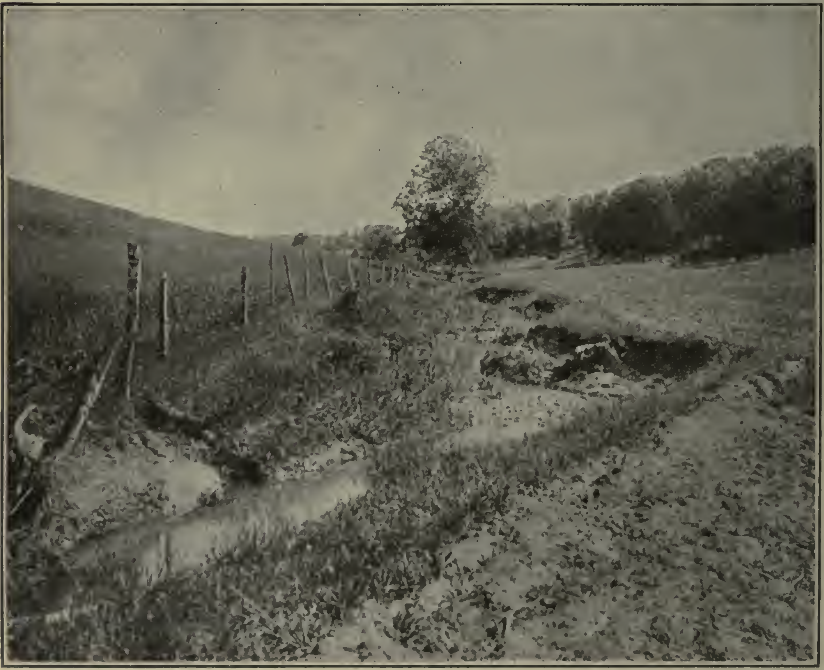

FIG. 6.—A comparatively small stream sometimes cuts out a wide strip of land from the productive area of a farm. Here a straight ditch would increase the field area and facilitate field operations.

methods of reclamation,[1] often remain untillable because of lack of means, skill, or equipment necessary to put them in suitable shape, and sometimes because owners believe that it would not be worth while to try to clear them. (See Figs. 6, 7, and 8.) In handling such an area the probable cost of bringing it under the plow should be carefully compared with the market value of good arable land in the neighborhood. In this way can be ascertained whether or not reclamation would be profitable.

WOODLAND.

Woodland is ordinarily productive land, but often farm wood lots producing only firewood for home consumption are maintained under uneconomic conditions. The more valuable the land, the more likely this is to be the case. Where timber occupies high-priced land which would be tillable if cleared, it is often questionable whether it is economic to allow it to remain. The cost of clearing, salable value of timber products, interest on the investment, prospective increased farm value of the land when cleared, and added annual expense for firewood must be weighed carefully before a decision can be reached in any such case.

FENCE ROWS.

Where field fences exist they ordinarily occupy land that would otherwise be utilized for productive purposes, and unless they are indispensable to the business of the farm they often may be eliminated with profit and the land they occupy made available for productive purposes. In the aggregate a large area of tillable land is taken up by fences, but until recently very little attention has been given by agricultural writers to the economic aspect of this subject. Bulletin 321 of the United States Department of Agriculture [2] deals fully with the economy of fences. (See figs. 9 and 10.)

It will be seen by the table below that some types of fence occupy much more land than others. On a number of farms in central Illinois, in a region where the land is tilled as close as possible to the fences, careful measurements taken give the following figures:

Kind of fence.	Average width of strip of land occupied.		Number of rods of fence occupying 1 acre.
	Ft.	*In.*	
Barbed wire	5	7	473
Woven wire	5	9½	459
Trimmed hedge	6	10½	384
Board	7	6	352
Zigzag rail ("worm")	12	4	214
Untrimmed hedge	12	8	209

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[1] See reference list of publications on draining and clearing farm land at end of bulletin.

[2] Cost of fencing farms in the North Central States, by H. N. Humphrey. Dep. Bul. 321.

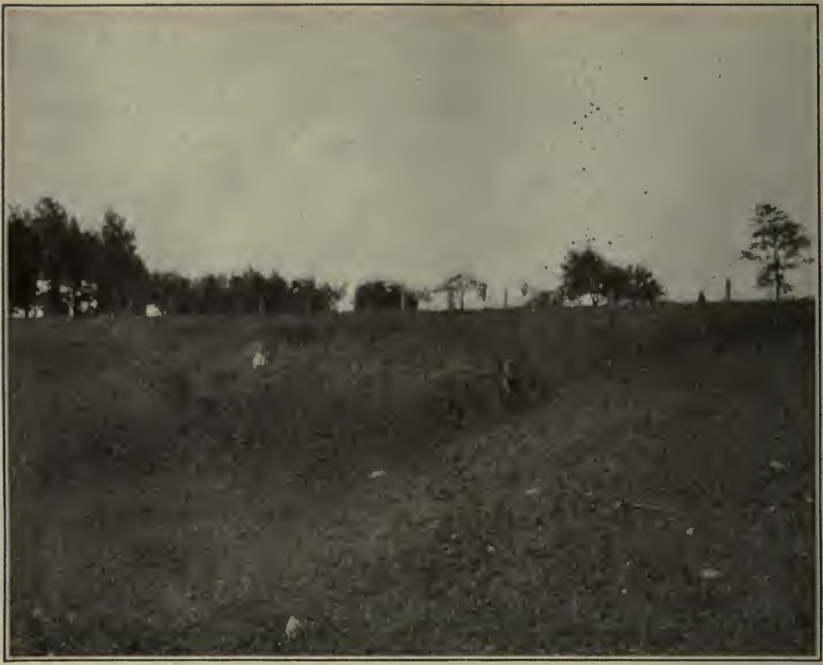

FIG. 7.—One of the results of bad tillage methods. A badly gullied field, best utilized for pasture. A little attention when this wash began would have stopped it. A place for a brush dam.

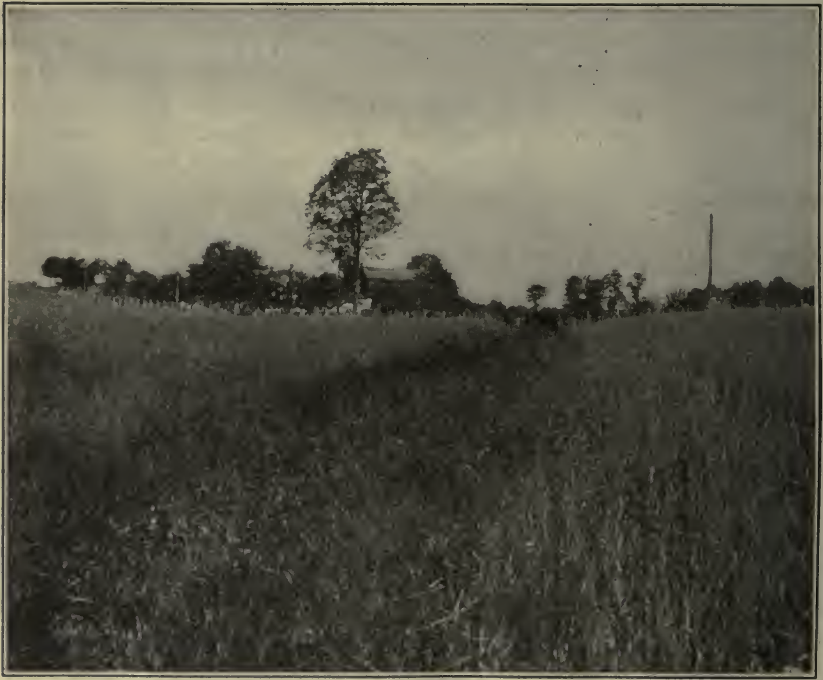

FIG. 8.—A stream, heading at a spring near the barn in the background, makes waste a wide strip through this fertile field. Drain tile needed here.

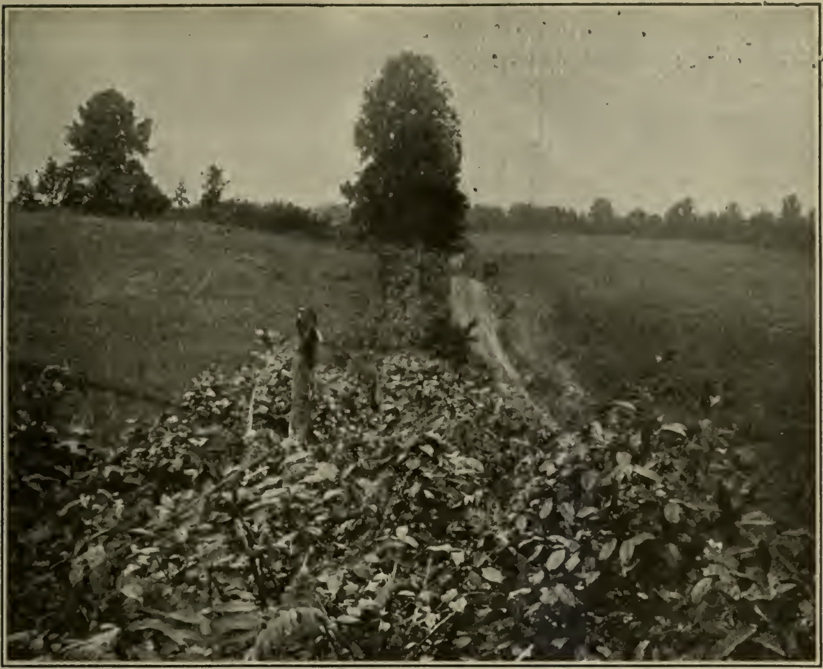

FIG. 9.—A volunteer hedge which should be eliminated. A fence-row overgrown with brush, bordering a farm lane. The two take out of the productive area of this farm a strip of land 50 feet wide and three-fourths mile long.

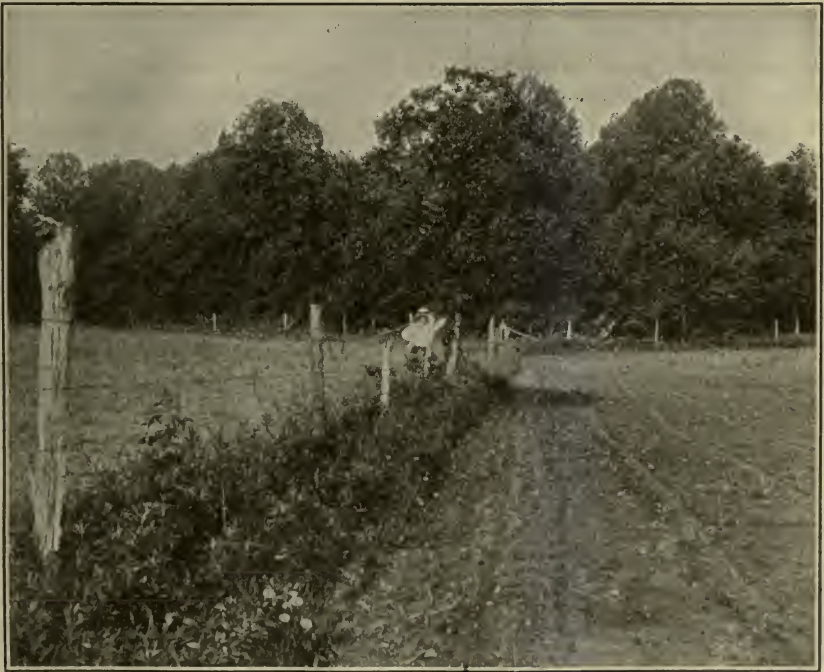

FIG. 10.—Waste of land entailed by a fence between two tilled fields under average farm conditions. The fence-row is 7 feet wide.

It will be seen that there is a wide variation in the width of the strip occupied by various styles of fence. Untrimmed hedges are much more wasteful of land than the table shows, as it is found that crops are injured by the hedge roots as far out as 20 feet on each side in some instances. Zigzag rail and stone fences also have an additional disadvantage, as they harbor weeds, rodents, insects, and other enemies of efficient farming.

HEADLANDS AND TERRACES.

The practice of leaving headlands or turning spaces at the edges of fields is a wasteful one, widely followed in some of the newer agricultural regions. The land thus taken up produces nothing and is practically wasted. The old-fashioned terraces common in the cotton belt are uneconomic in that they occupy tillable land and harbor weeds. By many they are considered necessary to the cotton-belt types of soil and agriculture; but a large number of farms exist in which they have been entirely eliminated. Where they are actually necessary it would seem that the tilled or "Mangum"[1] terrace is far more to be desired than the ordinary weed-covered, pest-propagating kind.

UNECONOMIC PASTURE LAND.

In many cases land is given over to use as pasture which will not support sufficient stock to make any reasonable return on the investment. (See fig. 5.) Such land properly belongs in the category of nonproductive land, in that it makes no return commensurate with the interest on the money invested.

It should be borne in mind that the quality of the pasturage in relation to the land value is an important consideration in choosing a farm. For instance, what is economic pasture on land that is worth $10 per acre might, on land valued at $100 an acre, be decidedly uneconomic. This relation should be carefully studied in buying a farm with much pasture land. To determine whether pasture land is economic or not, practical data should be secured as to the number of acres necessary to support one head of stock and the interest on the value of the land in question compared with the current charge per head of the same kind of stock for a season's pasturage. Or the estimated value of the return in increased value of the stock or its products may be used for comparison. By this means the relative economy of pastures may be determined.

A STUDY OF LAND UTILIZATION ON 1,703 FARMS.

During the past half-dozen years the Office of Farm Management has cooperated with farmers in several of the States in the keeping of cost records. In each case an accurate map was made of the farm of the cooperator for determining the exact division and distribution of the land composing the farm. Table III shows the average proportion of the land utilized by crops, farmstead, roads, pasture, woodland, and waste lands on 99 of these farms in five States along our northern boundary. Farmers in seven other States were cooperated with, but in no one of these States was there a sufficient number to give a significant average.

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[1] See "The Mangum Terrace," by J. S. Cates, B. P. I. Cir. 94.

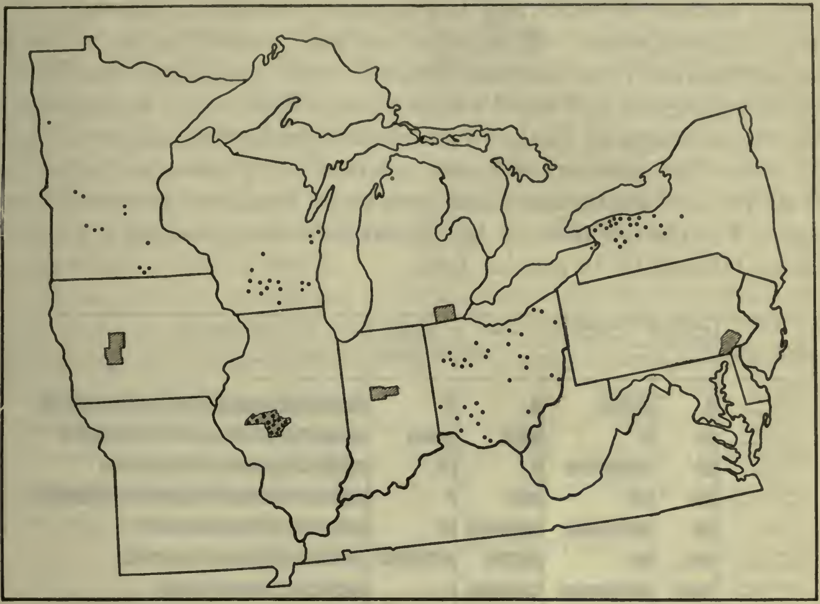

FIG. 11.—Location of 99 individual farms and 5 agricultural sections from which data were secured. Each dot represents a farm actually measured and each shaded area a locality where the survey method was used.

TABLE III.—*Utilization of land on 99 farms in five States.*

(From actual land measurements.)

Use of land.	Average number of acres per farm.					Relation to total area.				
	Western New York.	Ohio.	Central Illinois.	Southern Wisconsin.	Minnesota.	Western New York.	Ohio.	Central Illinois.	Southern Wisconsin.	Minnesota.
						Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total acreage..	131.55	193.29	191.00	170.04	263.10	100.0	100.0	100.0	100.0	100.0
Productive, total....	124.58	183.01	182.70	154.15	236.57	94.7	94.7	95.6	90.7	89.9
Tillable.........	107.77	109.40	156.70	86.86	188.60	81.9	56.6	82.0	51.1	71.7
In crops.....	105.32	101.89	148.68	82.88	183.54	80.0	52.7	77.8	48.8	69.8
Tillable pasture, fallow, etc...	2.45	7.51	8.02	3.98	5.06	1.9	3.9	4.2	2.3	1.9
Woods..........	9.68	33.73	2.38	29.93	11.87	7.4	17.5	1.2	17.6	4.5
Permanent pasture...........	7.13	39.88	23.62	37.36	36.10	5.4	20.6	12.4	22.0	13.7
Nonproductive, total	6.97	10.28	8.30	15.89	26.53	5.3	5.3	4.4	9.3	10.1
Farmstead......	2.30	3.21	3.91	4.13	7.97	1.8	1.6	2.1	2.4	3.0
Roads...........	3.21	3.03	2.94	4.51	5.17	2.4	1.6	1.5	2.6	2.0
Waste land.....	1.46	4.04	1.45	7.25	13.39	1.1	2.1	0.8	4.3	5.1
Number of farms....	22	33	15	17	12	22	33	15	17	12

Additional land-utilization data for farms in five States, from one of which data were secured by the cost-accounting method, are available from farm-management surveys. These data are shown in Table IV. Fig. 11 shows the location of the farms represented in Tables III and IV, each dot on the map representing one farm where actual measurements were made, and the shaded areas the localities from which date were secured by the survey method. These latter data were gathered by the customary Farm-Management survey method of recording the farmers' answers to carefully prepared interrogations. That this method secured fairly accurate land-utilization data becomes evident upon comparing the Illinois percentage figures in Table IV with those in Table III. It is probable that the averages in Table IV are more accurate than those in Table III, since the number of farms involved is 12 times as large. In Table IV the farmsteads, roads, and waste lands are grouped as one item. The chart shown in fig. 12 exhibits the percentages given in Tables III and IV in graphic form.

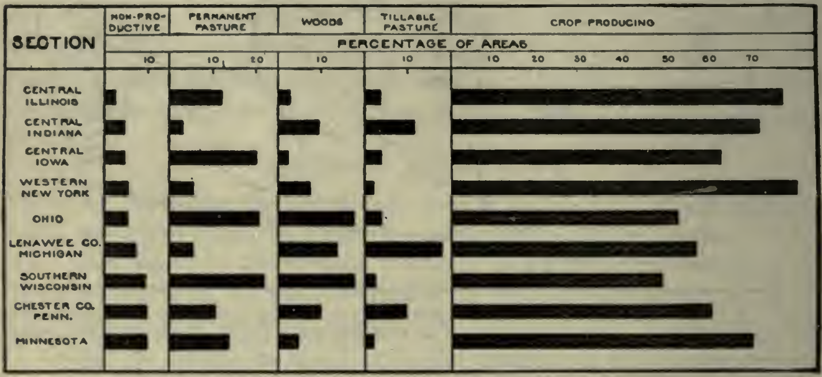

FIG. 12.—Chart showing average percentage of land on farms devoted to different uses in nine regions of the United States.

TABLE IV.—*Utilization of land on 1,604 farms in five States.*

(From data collected in Farm Management surveys.)

Use of land.	Average number of acres per farm.					Relation to total area.				
	Chester County, Pa.	Lenawee County, Mich.	Central Indiana.	Central Illinois.	Central Iowa.	Chester County, Pa.	Lenawee County, Mich.	Central Indiana.	Central Illinois.	Central Iowa.
						Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total acreage..	93.62	111.98	113.70	240.57	183.02	100.0	100.0	100.0	100.0	100.0
Productive (total)...	84.78	104.18	108.58	235.25	174.80	90.5	93.0	95.5	97.8	95.5
Tillable..........	65.48	83.03	94.57	198.80	133.82	69.9	74.1	83.2	82.6	73.1
In crops.....	56.36	63.07	81.31	187.00	126.72	60.2	56.3	71.5	77.7	69.2
Tillable pasture, fallow, etc...	9.12	19.96	13.26	11.80	7.10	9.7	17.8	11.7	4.9	3.9
Woods..........	9.29	14.97	10.63	7.02	4.14	9.9	13.4	9.3	2.9	2.3
Permanent pasture...........	10.01	6.18	3.38	29.43	36.84	10.7	5.5	3.0	12.3	20.1
Nonproductive (farmstead, roads, and waste land)...	8.84	7.80	5.12	5.32	8.22	9.5	7.0	4.5	2.2	4.5
Number of farms....	502	453	262	180	207	502	453	262	180	207

There is considerable variation in the way the land is utilized in the different regions studied, as shown in Tables III and IV. This is due to the varying types of agriculture, the diversity of natural conditions, the price of land, and the length of time that agriculture has been practiced in each region. Where the land is practically level, mostly free from timber, and well drained, a large proportion of it is naturally in crops. Where the country is hilly, more woods and permanent pastures are found, as these are the most profitable uses to which much of the land can be put. In the newer agricultural regions there are comparatively large areas of nonproductive land, as the land is cheap and therefore there has not been the same necessity to bring every available acre under the plow as in the older areas where land is high priced.

These data on utilization of land, when examined in relation to the types of agriculture prevailing in the regions studied, show that in general the business of farming is almost invariably adapted to existing conditions. Economic pressure is a force that must be reckoned with, and as a rule, any attempt to go against its laws will necessarily result in failure. Therefore the majority of farmers in any region fall naturally into a type of farming economically suited to that region.

INFLUENCE OF LAND TENURE.

There are three well-defined general systems of tenure of farm land:

1. Where all the land is owned by the operator.
2. Where all the land is rented by the operator.
3. Where part is owned and part rented.

Table V shows how the land is utilized on the farms studied in the corn-belt States of Indiana, Illinois, and Iowa under these three different systems of tenure. This table shows that, on the farms studied, the man owning one place and renting additional acres makes a better utilization of his land than either a tenant or owner, while both the tenants and the part owners are more efficient in this respect than the owners.

The economic reasons for this showing are not difficult to find. While owners operating average-sized farms get along without efficient utilization of their farm land by reason of having no rent to pay (in other words, by living partly on the interest on their investment), the tenant or small-farm owner renting additional land must so utilize the leased land he farms as to pay the rent and leave a remainder sufficient for his own expenses.

TABLE V.—*Variation in land utilization under different systems of tenure on 649 farms in three corn-belt States.*

(In terms of percentage of average farm area.)

State and system of tenure.	Number of farms.	Proportion of land devoted to each use.			
		Cropped.	Tillable.	Productive.	Nonproductive.
Indiana:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Owners	123	69.0	81.1	94.7	5.3
Tenants	83	72.3	83.3	96.0	4.0
Owners renting	56	75.3	87.2	96.4	3.6
Illinois:					
Owners	73	70.2	76.0	97.6	2.4
Tenants	71	83.8	87.7	97.8	2.2
Owners renting	36	82.6	87.3	98.2	1.8
Iowa:					
Owners	77	63.3	69.5	95.2	4.8
Tenants	93	71.0	72.5	95.5	4.5
Owners renting	37	76.3	81.6	96.1	3.9
Average for three States:					
Owners	273	67.8	75.5	96.0	4.0
Tenants	247	75.7	80.4	96.4	3.6
Owners renting	129	78.8	85.7	97.1	2.9

The tenant can not make as efficient utilization of land as the small owner renting additional land, since the tenant rents an entire farm and must usually take it as it is, productive and unproductive, tillable and untillable, and pay a rental sufficient to compensate the owner for his total investment, while the owner of a small place will naturally choose only tillable land in renting additional acres. Furthermore, the tenant can not afford to clear rough land, drain wet spots, etc., on a leased farm, while the small owner profitably can and usually does get every possible foot of his small holding on a productive basis. Using the average percentage of unproductive land on part-owner farms as a base, tenants had 24 per cent and owners 37½ per cent higher percentage of such land than part owners.

LOCAL VARIATION IN LAND UTILIZATION.

From the data shown and the foregoing discussion it will be seen that the utilization of land is largely governed by existing conditions, natural and economic, and that the average farmer in a given region will eventually of necessity follow a system in accordance with the conditions there. It must not be overlooked, however, that the personal element enters into the equation, and that both efficient utilization of land and the reverse may and do exist on farms of the same general type in the same region.

Table VI shows the variation in efficiency in land utilization on the most and the least efficient farm in this respect in each of the five regions covered in Table III. These data indicate the possibilities of good judgment in land utilization. In each section the most efficient farm has less than half the average percentage of land nonproductive, while the least efficient farm has more than double the average percentage nonproductive. While these variations are doubtless due in part to natural conditions, such as waste lands which it is impracticable to reclaim, they nevertheless indicate that there is need of good judgment in studying farms from the standpoint of efficient land utilization.

TABLE VI.—*Variation in efficiency of land utilization on individual farms in five States.*

[In terms of percentage of total farm area.]

Region.	Proportion of nonproductive land on—		
	Farm having least efficient land utilization.	Average of the region.	Farm having most efficient land utilization.
	Per cent.	*Per cent.*	*Per cent.*
Western New York	12.7	5.3	2.6
Ohio	13.6	5.3	1.6
Central Illinois	9.0	4.4	1.8
Southern Wisconsin	18.1	9.0	2.5
Minnesota	22.4	10.1	4.3

CONCLUSION.

The results of this study, based on area records from 1,703 farms distributed throughout nine States, serve to call attention to the fact that there are certain portions of any farm which contribute nothing to the farm income, and to suggest various ways through which more or less of such nonproductive land may be reclaimed on the average farm. The percentage of the total farm acreage occupied by these nonproductive areas varies widely in different regions, and even on different individual farms in the same locality; yet even at best, where farming has been developed to a high state of efficiency, it is not uncommon to see land wasted by inefficient farm organization.

Every nonproducing acre of tillable land that profitably can be made productive is a loafer acre and should either be put to work or sold. Otherwise the money tied up in it is dead capital. The size of the productive part of a farm is perhaps the most important factor bearing upon the solution of the problem of successful farming under average conditions, and every loafer acre reclaimed is that much added to the farmer's chance of making a good income.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE AND OF EXPERIMENT STATIONS OF INTEREST IN CONNECTION WITH THIS BULLETIN.

ON CLEARING LAND.

DEPARTMENT PUBLICATIONS.

Bur. Plant Indus. Cir. 25, The cost of clearing logged-off land for farming in the Pacific Northwest.

Bur. Plant Indus. Bul. 239, Cost and methods of clearing land in western Washington.

Dept. Bul. 91, Cost and methods of clearing land in the Lake States.

Farmers' Bul. 600, An outfit for boring taprooted stumps for blasting.

STATION PUBLICATIONS.

Kentucky Sta. Bul. 154, Blowing stumps with dynamite.

Minnesota Sta. Bul. 134, Land clearing.

Mississippi Sta. Bul. 159, Clearing pine land.

Washington Sta. Bul. 93, I. A preliminary report on some experiments in clearing logged-off land with a stump burner.
II. A promising method for destroying stumps and logs.

Washington Sta. Bul. 101, Methods of clearing logged-off lands.

Washington Sta. Pop. Bul. 40, Char-pit method of destroying stumps.

Washington Sta. Bul. 1, Spec. Ser., An experiment in clearing logged-off land by the aid of a donkey engine in 1908.

ON DRAINAGE.

DEPARTMENT PUBLICATIONS.

Farmers' Bul. 187, Drainage on farm lands.

Farmers' Bul. 524, Tile drainage on the farm.

STATION PUBLICATIONS.

Arkansas Sta. Bul. 32, Farm drainage.

Arkansas Sta. Bul. 104, Farm drainage.

Delaware Sta. Rpt., 1892 (p. 30, 31), Soil improvement caused by vertical drainage.

Indiana Sta. Bul. 57 (p. 81–100), The improvement of unproductive black soils.

Iowa Sta. Bul. 78 (p. 235–263), Drainage conditions in Iowa. Notes and tables on drainage engineering.

Michigan Sta. Spec. Bul. 56 (p. 467–510), Drainage.

Minnesota Sta. Bul. 110, Report on the installation of an experimental drainage system.

New Hampshire Sta. Bul. 118, Tile drainage.

New York Cornell Sta. Bul. 254 (p. 229–282, figs. 188–216), Drainage in New York.

Ohio Sta. Cir. 147, The cost of tile drainage.

Utah Sta. Bul. 123, Farm drainage, a manual of instruction.

Vermont Sta. Bul., June 1913 (p. 275–312), The principles of land drainage.

Wisconsin Sta. Bul. 138, Land drainage.

Wisconsin Sta. Bul. 146, Drainage conditions of Wisconsin.

Wisconsin Sta. Bul. 199, The principles and practice of land drainage.

Wisconsin Sta. Bul. 229, The right drain for the right place.

Wisconsin Sta. Rpt. 12th, 1895 (p. 232–236), An experiment in draining low-lying marsh lands by means of a dike, a sump or reservoir, tile drains, and a windmill.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 746 JULY 6, 1916

OFFICE OF THE SECRETARY.

Contribution from the Office of Farm Management, W. J. Spillman, Chief.

THE FARMER'S INCOME.[1]

By E. A. GOLDENWEISER, *Statistician.*

SUMMARY.

A comparison of the farmer's income with that of other classes of workers is difficult because the farming business has not been entirely reduced to a money basis.

The average farm family has earnings, including house rent and the value of food and fuel supplied by the farm, about equal to those of the average industrial family, but the farmer has the advantage of a much lower cost of living and has, in addition to his earnings, the interest on the money he has invested in his farm business.

The wages of the average farmer are about $600,[2] composed of about $200 in cash and about $400 supplied by the farm. The average wage earner in a factory earns about $460, and the average salaried employee about $1,200. Thus the farmer's wages are higher than those of industrial wage workers but lower than those of salaried employees in industry. (See fig. 1.)

In view of the lower cost of living on the farm and the fact that two-thirds of the farmers have interest in addition to wages, it appears that farmers, as a class, are better off than the majority of persons engaged in other pursuits.

NATURE OF FARM BUSINESS.

The business of the farm is so complex and so different in many particulars from that of other enterprises that it is a difficult task to measure the income earned by farmers in terms comparable to

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[1] This bulletin is based on a circular on this subject by W. J. Spillman, issued July 19, 1913, on Bulletin No. 635, entitled "What the Farm Contributes Directly to the Farmer's Living," by W. C. Funk, and on statistics collected by the Office of Farm Management and the Demonstration Service, of this department, by the Bureau of the Census, the Bureau of Labor, and the Immigration Commission.

[2] See pp. 5 and 6.

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incomes of persons in other pursuits. The farmer lives at his place of business and pays no cash rent for the use of his house, while his fields and groves are nearly as much a part of his residence as the rooms in the farm dwelling. The farmer derives two-thirds of his food and fuel from the farm and pays no cash for them. When a value is placed on these items it is a wholesale farm value, which is much less than the price paid for the same articles by the city dweller, who has to pay in addition a series of transportation charges, commissions, and profits of middlemen. Furthermore, the products supplied by the farm are generally superior in quality to those obtained at groceries by the average city dweller. It is impossible, however, to place a correct money valuation on this difference.

The farm owner's capital is his farm. This includes not only his real-estate investment but also his entire working capital. The farm generally represents all of his savings and the inherited savings of his ancestors. The income derived from the farm is composed, from this point of view, of four different elements—the cash earnings of the farm family during the year under consideration, the living supplied by the farm, the annual return on the accumulated savings of the farmer's own life, and the annual returns on the inherited savings of his forbears.

In comparing the farmer with the city man who draws a weekly wage for his labor and spends it in providing the necessities of life for his family, the outstanding difficulty involved is the fact that the farm business has as yet not been reduced altogether to a money basis. The city man sells his labor for money and buys all he consumes at the cost of money. He invests whatever savings he may have or whatever capital he may have inherited in enterprises that often have no connection whatever with his own activities. In other words, the city man's life has been entirely reduced to a commercial basis, his income and outgo may be measured in terms of the medium of exchange, while the farm is still to a large extent a self-sufficient unit producing values not all of which have been reduced to exchange prices and an income that contains elements measurable only by the amount of satisfaction derived by the owner.

The comparison of the earnings of farmers with those of other classes of population, which is attempted in this bulletin, can be, in view of the foregoing considerations, only of a very general nature, and the results are only approximately representative of actual conditions.

EARNINGS OF FARM FAMILY.

It is estimated on the basis of the census figures that the total value of crops produced in 1909 by the 6,362,000 farmers in the United States and not fed to live stock amounted to about $3,250,000,000. The value of the live-stock products of the farms was $1,125,000,000, and the value of animals sold and animals slaughtered on farms, $1,833,000,000. The total gross income derived by farmers from all these sources was about $6,208,000,000, or $976 per farm. In this item are included such portions of the farm products consumed at the home farms as the census enumerator was able to estimate, but the total falls short of the full amount of the farmer's income by the omission of the milk and cream consumed on the home farm and of a large proportion of the vegetables, fruit, and poultry. Furthermore, the figure includes no allowance for the fuel and use of the house. The aggregate of these additional items has been estimated at $1,654,000,000, or $260 per farm, making a total gross income of $1,236 per farm. Out of this gross income the average farmer pays $512 in farm expenses, including labor, fertilizers, feed, animals purchased, etc., and the cost of repairs and depreciation charges, leaving a net earning of $724 available for family expenses, payments on mortgage, and savings. After deducting interest on the investment at 5 per cent ($322), there is left $402, the income produced by the labor of the farm family.

In arriving at this average all the farms of the United States were included, and the figure is affected by the financial losses sustained by the estates of wealthy persons who farm for amusement, by the small farm incomes from suburban farms whose owners earn their living by occupations other than farming, and by the low wages of small tenant farmers in the South, where tenantry in many cases is simply a method of hiring labor. Furthermore, the $402 include no earnings derived from pursuits other than farming, an item that is important in certain regions in which even genuine farmers often engage in lumbering or other outside work in addition to their work on the farms. There is no doubt, therefore, but that this figure is lower than the true average income of typical farmers throughout the country.

The Office of Farm Management has made intensive studies of 4,018 farms in widely scattered sections of the United States. In each region selected all the farms were investigated, but the regions themselves generally represent better than average conditions. The average earnings of these farm families were $952, of which about $400 represented the value of the house rent and of food and fuel supplied by the farm, and about $550 the cash income of the farm family. The two figures, $402 and $952, the one derived from a census of all farms, including many that are not bona fide farm enterprises, the other from a survey of sections in which the average farm ranks higher than the general average, may be considered as the extremes between which the true average lies. It is significant that the averages obtained by actual investigations of industrial families fall approximately halfway between these two extremes. Thus, a study of 25,000 families of wage earners made by the Bureau of Labor in 1902 shows an average income of $750 per family, and a study of 16,000 industrial families made by the Immigration Commission in 1909 shows an average of $721 per family. These figures are about what students of social conditions have determined upon as being the minimum necessary for the support of an average family. While the farm families of the United States thus seem to be making about the same amount as the industrial families, there are three factors resulting from the nature of the farm business that make the conditions of farm families more advantageous.

1. Owing to the fact mentioned above that the values allowed for the items supplied by the farm are wholesale farm values, the cost of living on the farm is much less than in the cities, and if the figures were based on retail city prices, the average would have been not less than $200 above that given. In other words, the average farm family saves at least $200 on its annual bill for rent, food, and fuel, as compared with a city family of the same size.

2. In addition to the income earned by the labor of the farm family, farm owners have the interest on their farm investment, which amounts to about $322 per family. About two-thirds of the farmers are owners and have the use of that money. It is true that out of their income they are obliged to make payments on their indebtedness, but this does not average more than $100 a year for the farms that have mortgages, and only about one-third of the farms are reported as being mortgaged. In practice the farmer does not distinguish between the interest on his investment and the earnings of his family, and the income available for his expenses is derived from both sources.

3. In addition to earnings and interest, the farmer benefits by increases that may occur in the value of his property. During the decade preceding 1910 the increase was enormous, amounting to over $20,000,000,000, or $2,000,000,000 annually, so that, assuming that the increase was evenly distributed through the decade, the average farm family had property valued at about $300 more in 1910 than in 1909. While this item does not directly increase the farmer's financial resources, for unless he sells his farm the money is not available, but his taxes increase; and while it is a question whether this increase in value is likely to continue long (and it seems probable that it will at least not continue at the same rate), nevertheless, in so far as the increase represents genuine value and not inflation, it is an increase in the farm capital, or in the earning power of the farm. It also has the advantage of strengthening the borrowing ability of the farmer, and thus increasing the amount of cash upon which he may draw. That the rise in farm values exerts a decided influence

on the economic conditions affecting farming is seen from the fact that in many regions landlords are content with very small cash returns on their investment in the expectation of making up the difference in the increase in the value of their property.

To sum up, it appears from the discussion that the average farm family makes approximately as much for its labor as the average industrial family, but owing to the lower cost of living on the farm and to the interest earned by the farm investment, the average farm family occupies a much more secure economic position than does the average city family. This statement refers to averages, and it should be remembered that a great many farmers fall far below those averages while others rise far above them. In a study of 4,400 farmers conducted by the Farm Demonstration Service of this department, it was shown that the most successful fifth of the farmers made about four times as much as the next to the least successful fifth, while the poorest fifth made considerably less than the interest on their farm investments. While it is doubtless true that the distance separating the richest from the poorest farmer is not as great as that separating the men at the lowest and at the topmost rung of the ladder in the industrial world, nevertheless there is a wide range of variation in prosperity even among farmers.

THE FARMER'S WAGES.

In order to compare the wages earned by the farmer himself with those earned by the worker in other industries, the value of the unpaid labor of the farmer's family should be subtracted from the figures discussed in the preceding section. This item amounts to approximately one-tenth of the net earnings of the whole farm family. The farmer's wages, based on an average for the entire country, are approximately $360 a year, including food, fuel, and lodging furnished by the farm, while based on the farms included in farm management surveys they are $852 a year. If the real wages earned by the representative farmer of the United States were midway between these two extremes, his earnings would be about $600. This figure is below the average obtained by a study of 4,400 farms in the United States made by the demonstration service of this department. This average was $387 in cash, to which should be added about $400 in home supplies and rent, bringing the total up to about $800. Thus, $600 is a conservative figure for the farmer's wages and may be compared with the $518 earned by the average wage workers on full time in factories. When allowance is made for unemployment the factory workers average only $460 a year, and while this includes women and children employed in manufactures, as well as men, wage earners even in such occupations as iron and

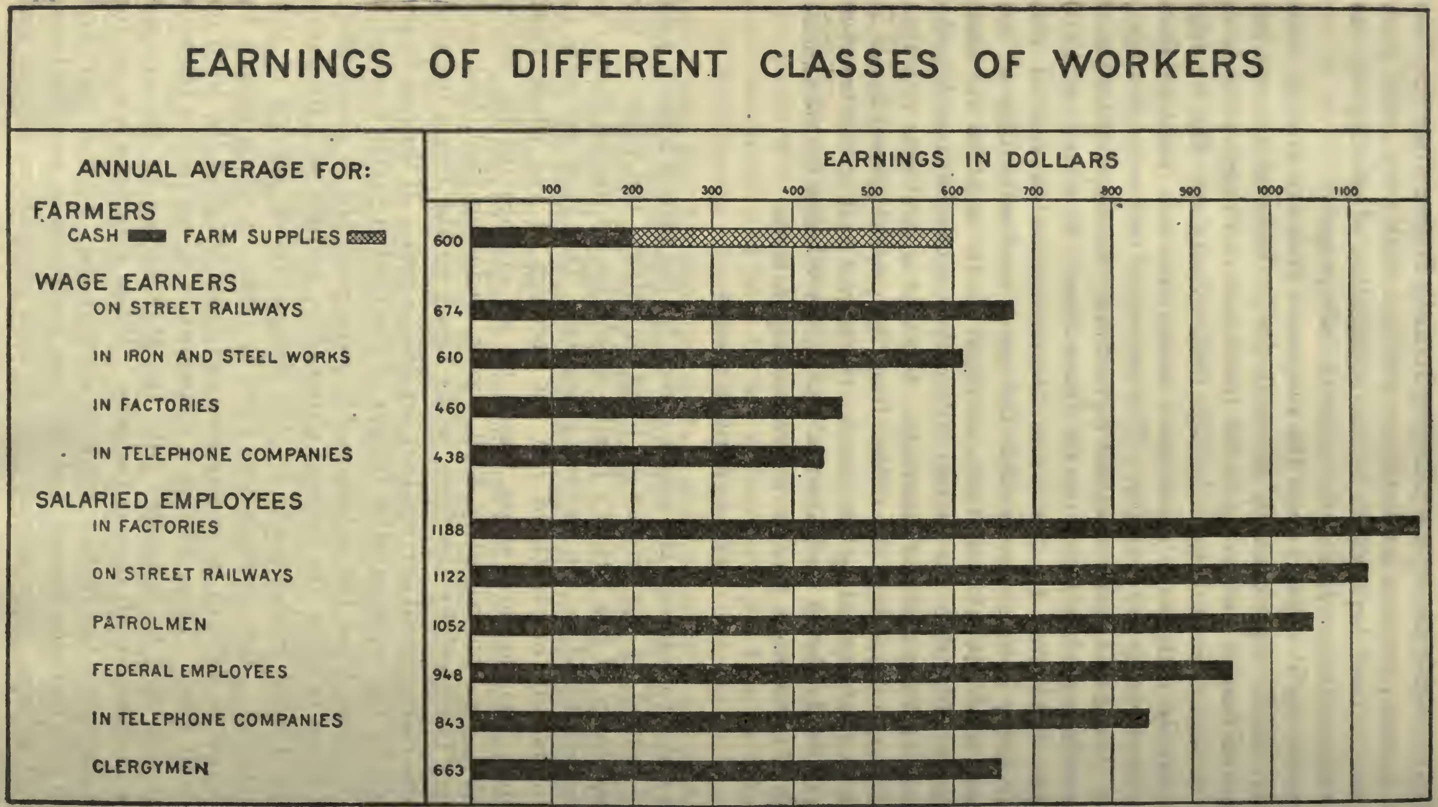

FIG. 1.—Earnings of workers compared. The first bar represents the approximate average earnings of farmers as estimated in this bulletin; the black section represents cash, and the hatched section the value of rent and of food and fuel supplied by the farm. The other bars represent average earnings for different classes of workers for whom statistics are available. It should be borne in mind that the cost of living on the farm is low and that farm owners have, in addition to their wages, the interest on their investment.

steel works and rolling mills report average earnings, allowing for time off, of only about $610.

While the farmer's earnings are higher than those of most industrial wage earners, the salaried employees of factories, clerks, etc., who average $1,188 a year, have cash incomes above those earned by farmers. The farmer's earnings may be further compared with the $1,052 earned by the average patrolman on the police force in cities of at least 30,000 inhabitants, with the $948 earned by the average employee of the United States Government, and with the $663 earned by the average clergyman.[1]

The limitations of averages and the difficulties of comparison apply with the same force to the farmer's wages as to the earnings of the farm family, but in view of all the available evidence the conclusion seems justified that the farmer's earnings, all things considered, are greater than those of the average wage earner engaged in other occupations.

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[1] The figures introduced for comparison are all based on census reports. The number of persons involved and the years to which the figures relate are as follows: Street railway wage workers, 259,000 (1912); iron and steel workers, 240,000 (1909); factory wage earners, 6,615,000 (1909); telephone wage workers, 145,000 (1912); factory salaried employees, 790,000 (1909); street railway salaried employees, 23,000 (1912); patrolmen, 32,000 (1907); Federal employees, 186,000 (1907); telephone salaried employees, 39,000 (1912); and clergymen, 105,000 (1906).

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

GRASSHOPPER CONTROL

In Relation to Cereal and Forage Crops

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FARMERS' BULLETIN 747

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. October, 1916

ALTHOUGH grasshoppers are not usually noticed by the farmer until they have reached a considerable size, they begin to injure his crops immediately upon hatching from the egg. They should be detected and combated, therefore, while young and small, so that time, labor, and material, as well as crops, may be saved.

The destruction of grasshopper eggs by fall plowing, disking, or harrowing is recommended where practicable.

Hopperdozers or other grasshopper traps are sometimes partially effective where the lay of the fields and other infested areas will permit their use, but these appliances are seldom entirely satisfactory.

The best results can be obtained when all the farmers in a community cooperate.

The most practicable means of controlling grasshoppers is by the application of the poisoned baits described on pages 15 and 16 of this bulletin.

In the semiarid parts of the country, as in California and the Southwest, the poisoned baits should have water added to them to counteract the rapid drying and should be applied during the late afternoon.

Where the climate is moist, as in the Eastern and Southern States, the baits may be prepared without the water and applied during the early morning hours.

GRASSHOPPER CONTROL IN RELATION TO CEREAL AND FORAGE CROPS.

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PRINCIPAL KINDS OF GRASSHOPPERS INVOLVED.

MANY kinds of grasshoppers are injurious to grains, grasses, and forage crops throughout the United States. The more important are the differential,[1] the two-striped,[2] the Carolina,[3] the lessor migratory,[4] the pellucid or clear-winged,[5] the red-legged,[6] the California devastating,[7] the southwestern lubber,[8] the Florida lubber,[9] and the New Mexico long-winged grasshopper.[10]

In the following pages is given a short description of these grasshoppers and the regions in which they occur, together with their life history, the crops attacked, and measures for controlling them.

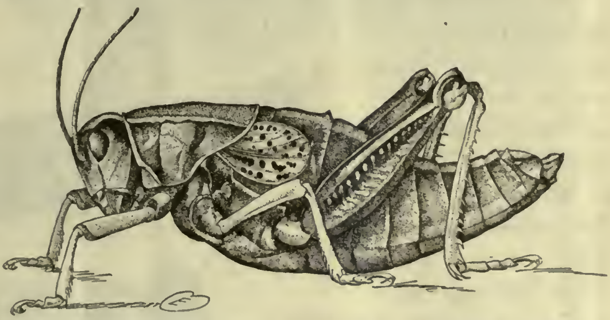

FIG. 1.—Southwestern lubber grasshopper (*Brachystola magna*): Adult female. Natural size. (Original.)

The southwestern lubber grasshopper (fig. 1), a very large species, lives in the semiarid regions of the Southwest. It is usually pale green in color, speckled and marked with pink and brown, and is wingless throughout its entire life. It sometimes becomes injuriously abundant on the cattle ranges and dry farms of New Mexico and Arizona, but is found throughout the Great Plains region from

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[1] *Melanoplus differentialis* Thom.
[2] *Melanoplus bivittatus* Say.
[3] *Dissosteira carolina* L.
[4] *Melanoplus atlanis* Riley.
[5] *Camnula pellucida* Scudd.
[6] *Melanoplus femur-rubrum* De G.
[7] *Melanoplus devastator* Scudd.
[8] *Brachystola magna* Gir.
[9] *Dictyophorus reticulatus* Thunb.
[10] *Dissosteira longipennis* Thom.

Wyoming and South Dakota to New Mexico and Texas. It is known to injure seriously corn, kafir, alfalfa, and grasses of various kinds.

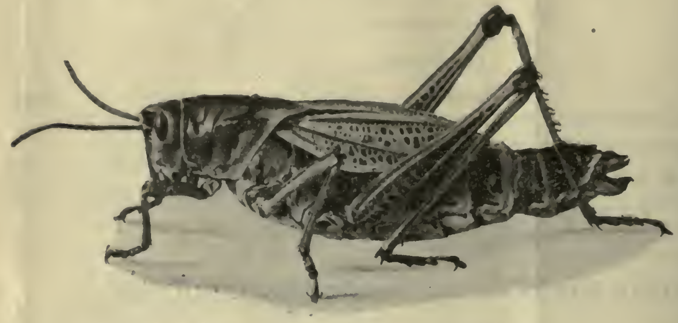

FIG. 2.—Florida lubber grasshopper (*Dictyophorus reticulatus*): Adult female. Natural size. (Webster.)

The Florida lubber grasshopper (fig. 2) is a clumsy insect, often reaching the length of more than 2½ inches, and is correspondingly robust. It is usually yellowish in color, prettily marked with black, and its short and nearly useless wings are more or less distinctly stained with a bright crimson color. It inhabits the southern United States from North Carolina to Texas and has been especially injurious throughout the newly reclaimed regions in the State of Florida. It has been found to attack corn, grasses, sorghum, cowpeas, soy beans, and other crops.

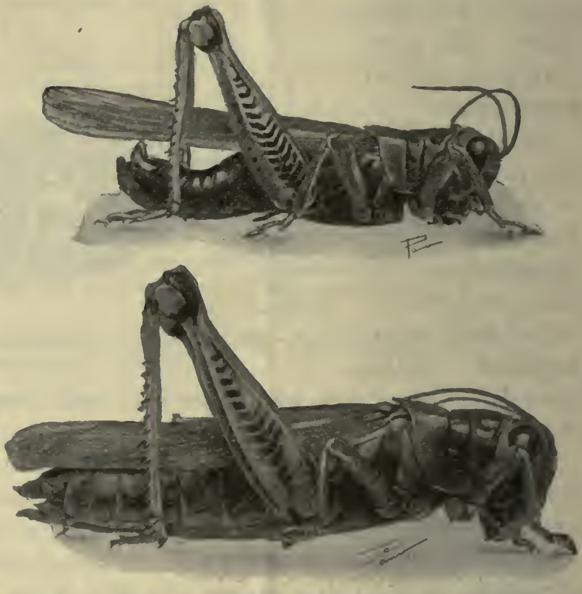

FIG. 3.—Differential grasshopper (*Melanoplus differentialis*): Above, adult male; below, adult female. Twice natural size. (Original.)

The differential grasshopper (fig. 3) is usually a yellowish-colored insect with clear glassy hind wings, averaging nearly 1½ inches in length. Its hind legs are usually distinctly marked with yellow and black, the colors arranged in chevron-shaped bars on the sides of the thighs. It is found throughout nearly the entire United States, although of rare occurrence in the Atlantic States. This grasshopper is chiefly injurious in the middle western and southwestern States, and is known to attack the following cereal and forage crops: Corn, sorghum, oats, wheat, bluegrass, soy beans, clover, and alfalfa.

The two-striped grasshopper (fig. 4) is a compact, yellowish species, bearing, as its name implies, two yellow stripes running from the forehead down each side of the otherwise brown back. It varies from 1 to 1½ inches in length and its hind wings are nearly colorless. This species is found from southern Canada to Mexico, excepting the South Atlantic States, and is very injurious to such important crops as wheat, corn, grasses, alfalfa, and clover.

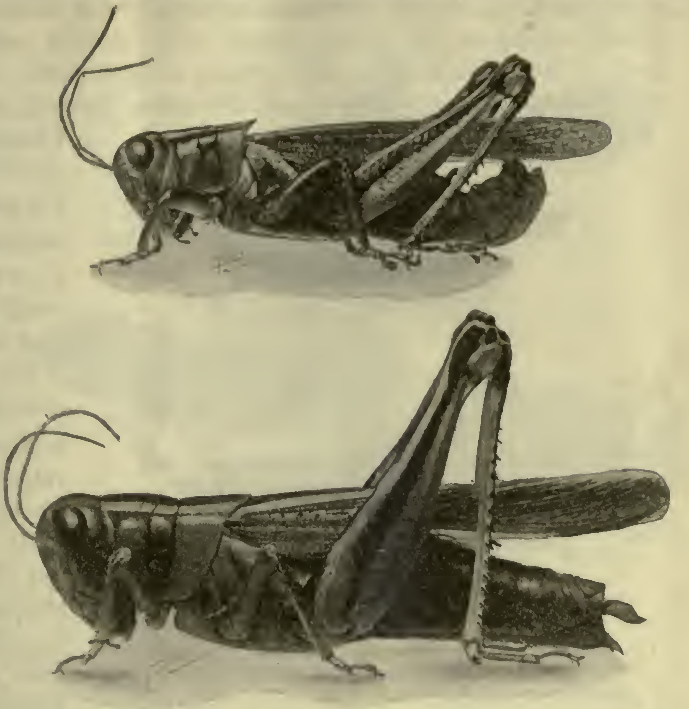

Fig. 4. — Two-striped grasshopper (*Melanoplus bivittatus*) : Above, adult male ; below, adult female. Twice natural size. (Original.)

The lesser migratory grasshopper (fig. 5) is a rather small, yellowish-gray species, averaging about 1 inch in length and bearing a distinct patch of black on the neck or collar. Although this grasshopper is comparatively small in size, it is a strong flier and sometimes does immense damage to alfalfa, grasses, timothy, corn, rye, soy beans, and wheat. It is found throughout nearly the entire United States, but is chiefly injurious in States west of the Mississippi River.

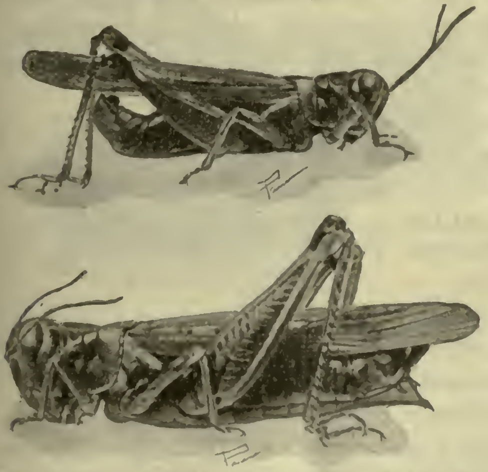

Fig. 5.—Lesser migratory grasshopper (*Melanoplus atlanis*) : Above, adult male ; below, adult female. About twice natural size. (Original).

The red-legged grasshopper (fig. 6) is one of the most widely distributed of all the injurious species. It is a small, yellowish insect, having its legs partly tinged with a bright reddish hue. Its back is brownish and the hind wings are colorless. It is found in considerable numbers throughout the entire United States, southern Canada, and northern Mexico, and is known to injure seriously wheat, corn, bluegrass, oats, rye, timothy, and soy beans.

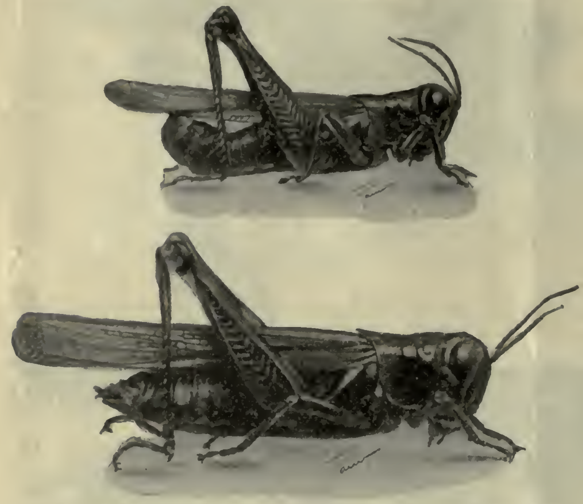

FIG. 6.—Red-legged grasshopper (*Melanoplus femur-rubrum*): Above, adult male; below, adult female. About twice natural size. (Original.)

The California devastating grasshopper (fig. 7) is a rather small species resembling somewhat the common red-legged grasshopper, but its injurious work is confined to the western United States, and especially California, where it frequently injures severely the alfalfa crop.

The Carolina grasshopper (fig. 8) is of moderate to rather large size, and is usually of a plain pepper-and-salt color, sometimes varying, in accordance with the soil upon which it is found, from gray through yellowish to a distinctly reddish color. Its hind wings are nearly black but are margined with yellow. Thus it is rendered inconspicuous while sitting upon the ground but catches the eye immediately upon taking flight. It is very widely distributed throughout the entire United States and is known to injure seriously corn, wheat, alfalfa, and soy beans.

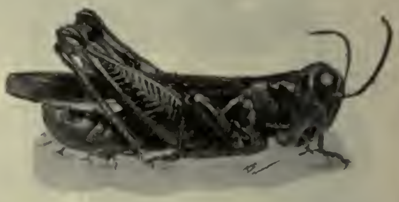

FIG. 7.—California devastating grasshopper (*Melanoplus devastator*): Adult male. About twice natural size. (Original.)

The pellucid or clear-winged grasshopper (fig. 9) is a small species having its hind, or true, wings clear or pellucid, while the front wings are distinctly blotched with brown. It is at times one of the most injurious species found within the limits of the United States. It has been especially injurious in the States of Idaho, Utah, and California, but is also found in Arizona and New Mexico. It is distributed throughout the northern United States from the Atlantic to the Pacific. This grasshopper is known to injure oats, wheat, grasses, and occasionally flax.

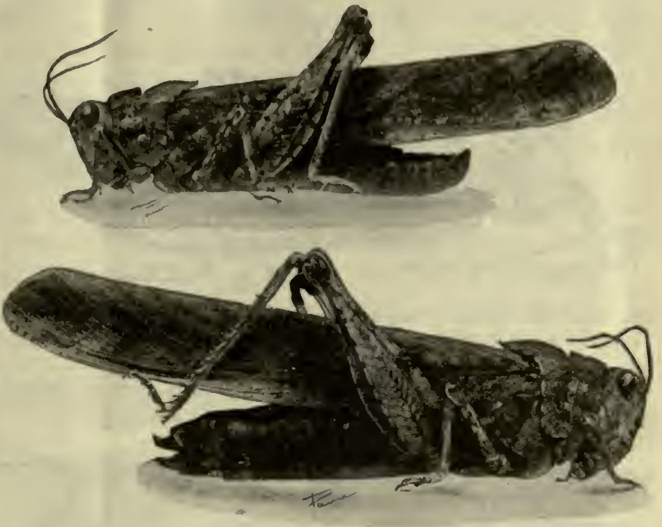

Fig. 8.—Carolina grasshopper (*Dissosteira carolina*): Above, adult male; below, adult female. About twice natural size. (Original.)

The New Mexico long-winged grasshopper (fig. 10) is a large, strong-flying species, often measuring more than 2 inches in length and is yellowish-gray, marked with chocolate-colored spots. It is known to exist in the central United States, from Idaho and Montana to New Mexico and Texas, and at times has been exceedingly injurious to the native grasses on the cattle ranges of New Mexico.

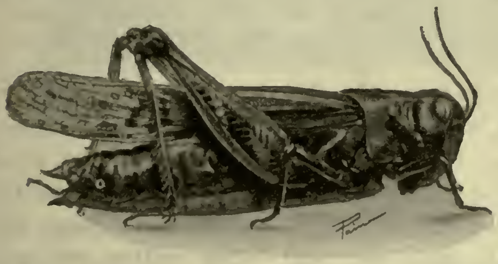

Fig. 9.—Pellucid or clear-winged grasshopper (*Camnula pellucida*): Adult female. About twice natural size. (Original.)

MANNER OF INJURY.

Grasshoppers, both young and old, injure crops in but one way, that is, by gnawing and devouring them wholesale, and where very numerous they have been known to consume almost every green thing in sight. Even the bark on the tender twigs of trees is eaten by these ravenous insects, which are known to gnaw the handles of agricultural tools, such as hoes and rakes, in order to secure the salt left upon them by the perspiring hands of the farmer.

CONDITIONS FAVORABLE TO OUTBREAKS OF GRASSHOPPERS.

It is generally believed in the middle and far western regions of the United States that when two dry summers occur in succession, the second one usually produces serious outbreaks of grasshoppers. Whether or not this be true, there is ample evidence to show that dry weather favors the successful hatching of the eggs and the subsequent development of these pests. On the other hand, cool wet weather is unfavorable, and grasshoppers often die in great numbers from disease when such weather conditions prevail.

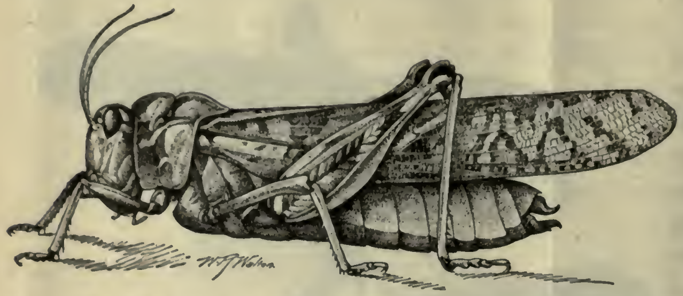

FIG. 10.—New Mexico long-winged grasshopper (*Dissosteira longipennis*): Adult female. About one-third enlarged. (H. E. Smith.)

LIFE HISTORIES AND DEVELOPMENT OF GRASSHOPPERS IN GENERAL.

The life histories of the various species of injurious grasshoppers are quite similar in character. The eggs are usually deposited in the soil, inclosed in sacs, or "pods" (fig. 11), formed of a glutinous substance furnished by the female. The grasshopper thrusts her tail or abdomen, which is capable of considerable extension, into the soil (fig. 12) and starts laying her eggs at the farther end of the tunnel thus formed, which is then filled with eggs and afterwards sealed. One grasshopper sometimes deposits a great many eggs. In the semiarid portions of the country, where the soil frequently becomes baked and hardened by the sun, the eggs are often laid in great numbers in the crowns of plants such as

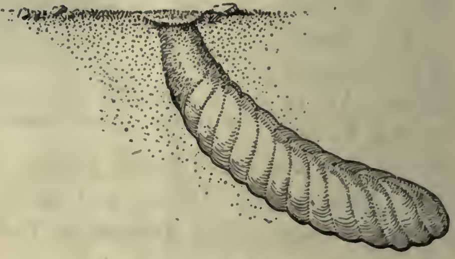

FIG. 11.—Sac, or "pod," of grasshopper eggs in the ground. Slightly enlarged. (Original.)

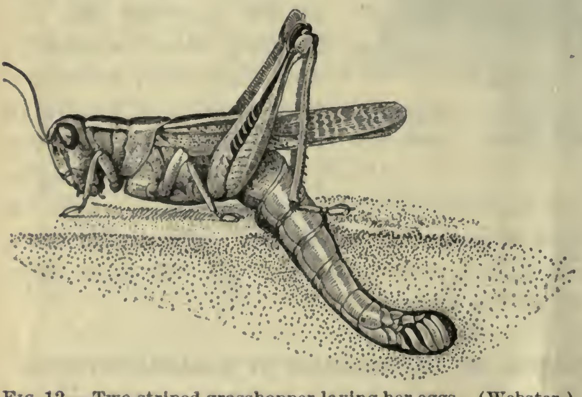

FIG. 12.—Two-striped grasshopper laying her eggs. (Webster.)

alfalfa, and in California as many as 2,000 eggs have been found in the crown of a single alfalfa plant.

The banks of irrigation canals are favorite egg-laying grounds for grasshoppers (fig. 13). In New Mexico and Arizona the eggs frequently are laid in the bottoms of shallow arroyos where they are inaccessible to cultivating implements. The waste lands of Idaho, Washington, and some other Northwestern States afford other instances where the destruction of grasshopper eggs is not practicable on a commercial scale.

The egg laying usually takes place in late summer or early fall and the young grasshoppers emerge the following spring. In some of the Southern and Southwestern States the young grasshoppers may emerge as early as February. In the North the eggs usually do not hatch until some time during the months of May or June.

In contrast with many other injurious insects, grasshoppers when hatched closely resemble their parents, excepting their lack of wings (fig. 14). There is no grublike larval stage nor is there any resting or true pupal stage such as is the case with butterflies and moths. The young grasshoppers are active and able to hop almost immediately upon emergence from the eggs. It takes from 70 to 90 days for the young grasshoppers to grow to maturity and develop wings. The farmer should therefore endeavor to attack the pest during its young stages, as this method not only requires less labor and material, but the insects can not then escape destruction by flying to untreated fields as they may, and often do, upon becoming mature. When the grasshopper reaches a certain stage of development its skin splits and is shed, the insect usually acquiring wings during the operation. It has then reached its final stage of growth and is ready to mate and reproduce its kind. So far as known the injurious species of grasshoppers have only one generation a year.

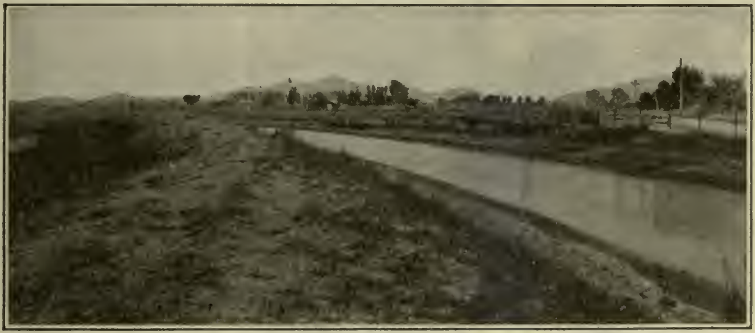

FIG. 13.—An irrigation canal right of way where crowns of alfalfa plants contain thousands of grasshopper eggs to the square foot. (Webster.)

NATURAL ENEMIES OF GRASSHOPPERS.

INSECT ENEMIES.

Several kinds of parasitic two-winged flies deposit their eggs or maggots upon grasshoppers in their mature or nearly mature stage.

FIG. 14.—Young grasshoppers feeding on clover. Slightly enlarged. (Original.)

Among the most important of these is a blowfly or meat fly (fig. 15), which has been observed to deposit live maggots upon the wings of the grasshoppers while they are in flight. The maggot of this parasite devours the internal portions of the grasshopper's body and soon causes its death. Robber flies (fig. 16) feed very largely upon young grasshoppers, grasping them in their long, stout legs, thrusting the strong beak through the body wall of the grasshopper and sucking out the liquid contents of the body. Several kinds of digger wasps (fig. 17) kill or stupefy grasshoppers by stinging, and then drag them into their underground nests, after which the wasp lays an egg upon the body of the grasshopper, which subsequently becomes food for the newly hatched grub. A number of blister beetles are known to prey in their younger stages upon the eggs of grasshoppers, but as the adult beetles are sometimes quite injurious to potatoes, beans, and other cultivated plants, they can not be considered as entirely desirable allies of the farmer.

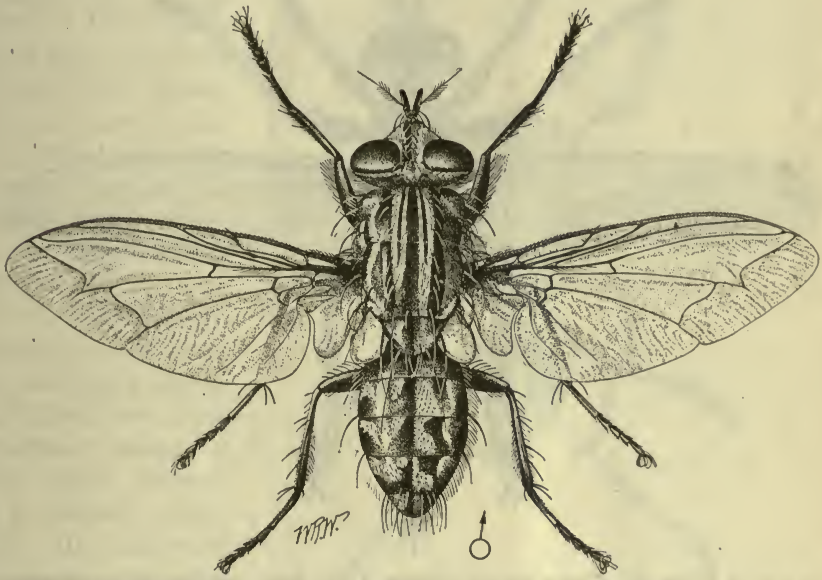

Fig. 15.—A two-winged fly, *Sarcophaga kellyi*, parasitic on grasshoppers: Adult. About six times natural size. (Kelly.)

WILD AND DOMESTIC BIRD ENEMIES.

The Bureau of Biological Survey has found that wild birds play a great part in the natural control of grasshoppers. These feathered friends of man are always present where grasshoppers abound and work almost constantly in aiding the farmer. The statement that all birds feed upon grasshoppers is so near the absolute truth that it needs only insignificant modifications. From the largest hawks to the tiny hummingbirds there are no exceptions other than the strictly vegetarian doves and pigeons. Although birds of all families prey upon grasshoppers, the following may be selected as the most important destroyers of grasshoppers for their respective groups: Franklin's gull, bobwhite, prairie chicken, red-tailed, red-shouldered, broad-winged, and sparrow hawks, the screech and burrowing owls, yellow-billed cuckoo, road-runner, nighthawk, red-headed woodpecker, kingbird, horned lark, crow, magpie, red-winged and crow blackbirds, meadowlark, lark bunting, grasshopper and lark sparrows, butcher bird, wren, and robin.

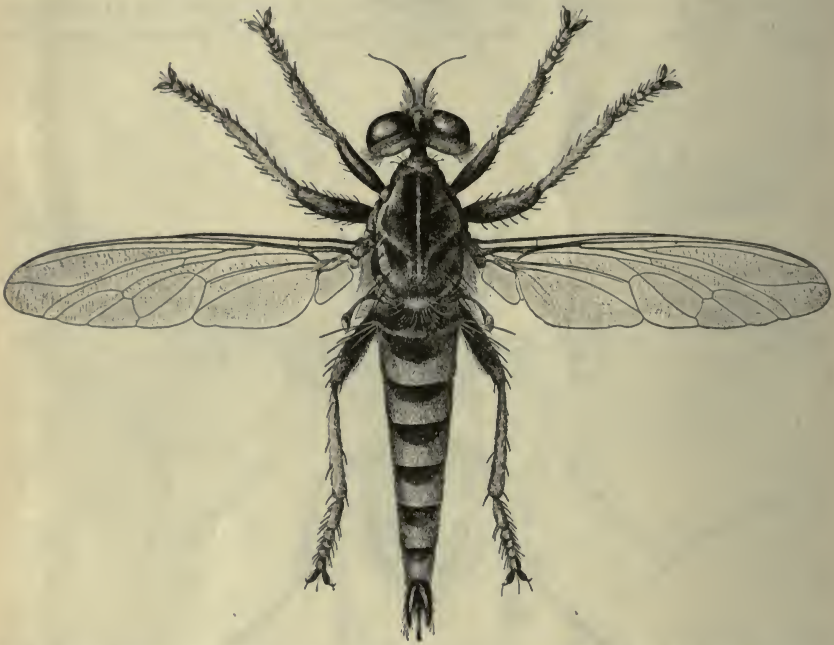

Fig. 16.—A robber fly, *Promachus vertebratus,* which preys upon young grasshoppers: Adult. About three times natural size. (Original.)

Domestic fowls are also very fond of grasshoppers and feed greedily upon them whenever possible. Turkeys are sometimes killed by eating too freely of grasshoppers, the strong, rough hind legs of which cause severe lacerations or even puncturing of the crops of the birds.

HISTORICAL.

There exists ample evidence showing that grasshoppers, or locusts, as they are most often called in the Old World, have been reckoned among the principal insect enemies of agriculture since man began to till the soil. The writings of the Egyptians, Greeks, and ancient Hebrews all contain references to these insects as hateful pests of the farmer. In North America unmistakable representations of grasshoppers are found on pottery and in the picture writings of the prehistoric Indians and Aztecs. It is therefore quite probable that grasshoppers attacked the maize and other crops of the Indians long before the coming of the white man. The early history of the New England States affords numerous records of the inroads by grasshoppers upon the crops of the settlers. During the period 1743 to 1756 a great scourge of these hungry insects occurred in Maine, and other outbreaks occurred in Vermont during the year 1797 to 1798. When agriculture began to be established generally in the Great Plains region of the United States, lying west of the Mississippi River and east of the Rocky Mountains, during the decade 1870–1880 a migratory species of grasshopper, commonly known as the Rocky Mountain locust,[1] frequently swooped down from its breeding grounds on the benches of the mountain range in such great swarms as to destroy practically all cultivated crops over vast areas of country. As the settlement of the Rocky Mountain region progressed and the breeding grounds of this destructive insect came under the influences of cultivation these outbreaks ceased. Thus, there has not been a serious general outbreak of the Rocky Mountain locust since 1880, and this particular grasshopper has ceased to be a pest of any great importance.

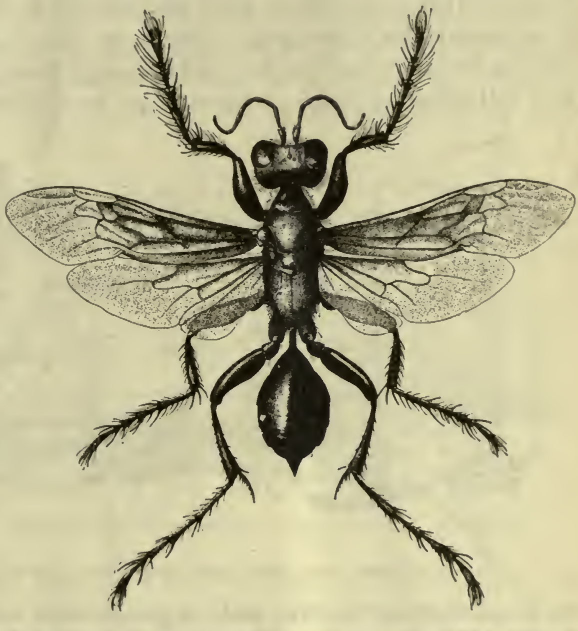

FIG. 17.—A digger wasp, ***Prionoyx atratus,*** which kills or stupefies grasshoppers by stinging them, and carries them into its nests as food for its young. Nearly three times natural size. (Original.)

However, there are many other kinds of grasshoppers having different habits which have since hampered the farmer and undoubtedly will continue to rob him of his crops for years to come unless persistent concerted action of agricultural communities in combating these pests succeeds in securing permanent relief.

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[1] *Melanoplus spretus* Uhl.

CONTROL MEASURES.

There are three principal methods of control which have been found to be of greater or less practical value in combating grasshoppers in this country: First, the destruction of the eggs; second, catching the insects in the field by means of traps; and, third, the use of the poisoned baits.

DESTROYING THE EGGS OF GRASSHOPPERS.

It is seldom practicable to destroy the eggs because of the many different hiding places chosen by the grasshoppers in laying them and the impossibility of reaching the same with cultivating implements. However, where they are accessible the ground containing them should be thoroughly plowed, or disked, and harrowed in the fall, as these operations prevent the eggs from hatching successfully the following spring. Attempts to reach the eggs by handwork, such as digging up the soil, is practicable only in gardens, truck farms, and places where intensive cultivation is practiced.

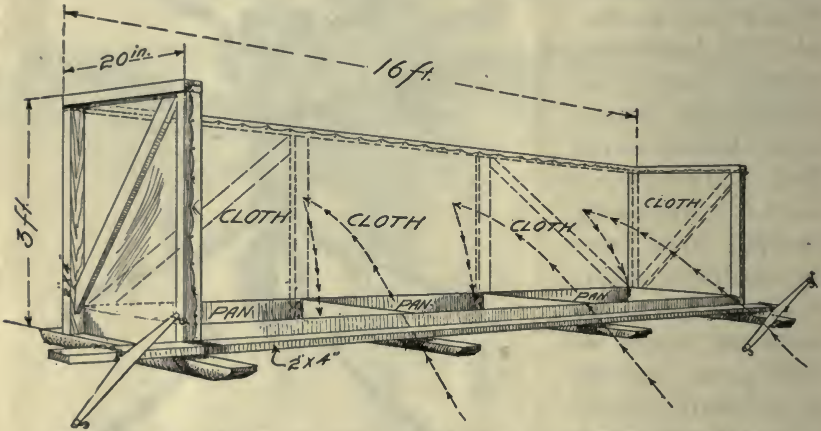

Fig. 18.—Hopperdozer with cloth back, showing construction. (Original.)

MECHANICAL MEANS OF DESTROYING GRASSHOPPERS.

The most common method of destroying grasshoppers mechanically is by the use of a simple horse-propelled implement or trap commonly called a hopperdozer. These implements are constructed along similar lines, but are of many slightly different patterns. As originally built the hopperdozer consisted of a galvanized sheet-iron pan or trough having a back rising at right angles to the pan. It was about 16 feet in length and mounted on runners made of wood or old wagon tires. Most of the hopperdozers recently constructed have a pan made of galvanized sheet iron, but the back and side wings are usually built with a wooden frame covered with stout muslin or light cotton duck, thus securing lightness and elasticity of structure. (Fig. 18.) The pan of the hopperdozer is kept partially filled with water, upon which a film of low-grade kerosene, or coal oil, is maintained. When the implement has a cloth back and wings, these are kept moistened with kerosene oil. As the hopperdozer is drawn over the ground the grasshoppers jump or fly against its back and most of them are precipitated into the oil-covered water in the pan. A slight touch of oil is fatal to the insects. Thus, those that merely touch the oil-soaked back of the hopperdozer are usually killed, although they may not die immediately. The cheapest procurable grade of kerosene oil is perfectly satisfactory for use in a hopperdozer. An implement of this kind has been constructed recently with a back curving slightly forward. (Fig. 19.) The back and sides of this implement are covered with tin, nailed to furring strips carried by the uprights of the frame. It has been used successfully in western States, and it is claimed that the slight curve of the back and the slippery surface of the tin aid in precipitating the grasshoppers into the pan. As many as 300 bushels of grasshoppers have been collected by the use of hopperdozers on 100 acres of alfalfa. But even where these implements may be used successfully, a great many grasshoppers escape being killed by them, and the fact that hopperdozers can not be used on uneven, stony, or recently cleared, stumpy ground, nor in meadows or fields of grain where the crops have reached a considerable height, makes it imperative that some more effective method of control be applied, and the poisoned baits have been found to supply this need satisfactorily.

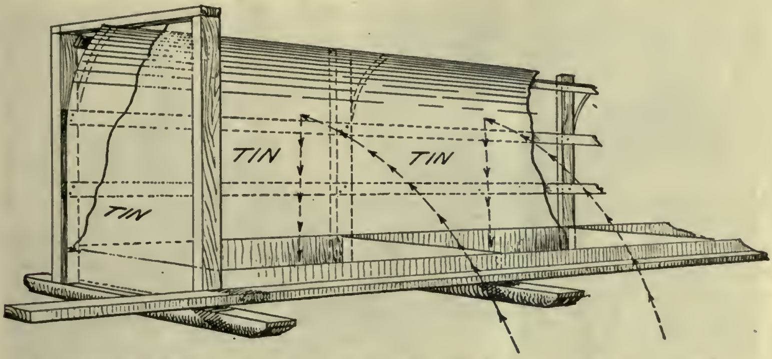

FIG. 19.—Showing construction of hopperdozer with tin back. (Original.)

POISONED BAITS AS A MEANS OF GRASSHOPPER CONTROL.

The mixture known as the poisoned-bran bait has been proven to be a simple, reliable, and cheap method of destroying grasshoppers, and has been applied with signal success throughout many portions of the United States. As prepared for ordinary use this bait is composed as follows: Wheat bran, 25 pounds; Paris green, 1 pound, or white arsenic, 1 pound; lemons or oranges, 6 finely chopped fruits; low-grade molasses, such as refuse from sugar factories, or cattle molasses, known as "black strap," 2 quarts. The bran and Paris green or other arsenical are thoroughly mixed while dry, the fruits are then finely chopped and added, and lastly the molasses is poured over the bait and the whole thoroughly kneaded. A coarse-flaked bran is most desirable, although where this can not be obtained easily ordinary middlings or alfalfa meal may be substituted; a low-grade, strong-smelling sirup or molasses, however, is essential to the entire success of the undertaking. Crushed ripe tomatoes, watermelons, or limes may be substituted for the lemons or oranges, if necessary. Ordinary powdered white arsenic (arsenious acid) contains nearly twice as much arsenic as Paris green and is comparatively low in price. The powdered form of arsenate of lead may be used, but in this case twice as much of it must be used as of the Paris green. In California and other semiarid regions water should be added to the bait at the rate of 4 gallons to 25 pounds of bran, as in these climates the bait dries out very rapidly and the extra moisture is necessary in order to attract the grasshoppers.

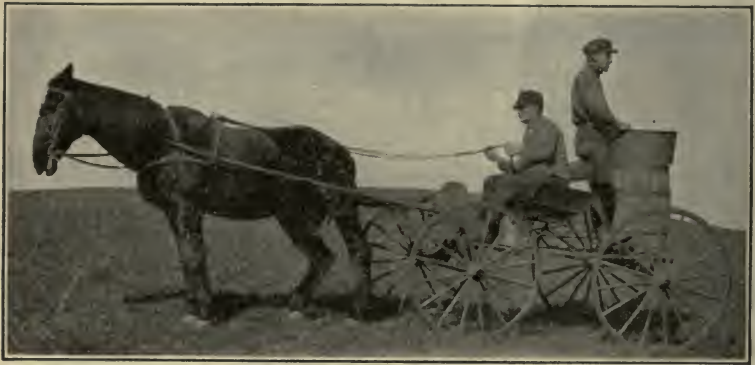

FIG. 20.—Sowing poisoned-bran bait from a buggy, in treating meadows to destroy grasshoppers. (Webster.)

Another effective bait of similar character is the modified Criddle mixture. This is prepared as follows: Fresh horse droppings, one-half barrel; Paris green, 1 pound, or powdered white arsenic, 1 pound; finely chopped oranges or lemons, 6 to 8 fruits. This bait must be thoroughly mixed before being distributed and as most people object to handling this mixture with the bare hands, a pair of cheap rubber gloves may be used for the purpose. Both the poisoned-bran bait and the modified Criddle mixture are distributed over the infested fields by sowing broadcast, either on foot or from a light wagon or buggy, as shown in figure 20. A broadcast grain seeder mounted on a wagon (fig. 21) has been used successfully for this purpose in the western portions of the country.

In applying the poisoned-bran bait in orchards, care must be taken to avoid distributing it close to the trees, because severe injury to fruit trees occasionally results from such applications of arsenical poisons.

Proper time for applying the poisoned baits.—The time of day chosen for distributing the poisoned baits has an important bearing upon the results secured. In California and other semiarid regions the bait should be distributed in late afternoon or early evening, just before the grasshoppers ascend the plants on which they usually pass the night. They are apparently hungry and thirsty at this time and greedily take the bait if it be available. In the moister portions of the country, such as New England and Florida, the bait is best applied early in the morning in order that the best results be secured. Farmers should not be discouraged if the grasshoppers do not drop dead immediately upon eating the poison, as it usually takes from one to five days for the full effect of the baits to become apparent.

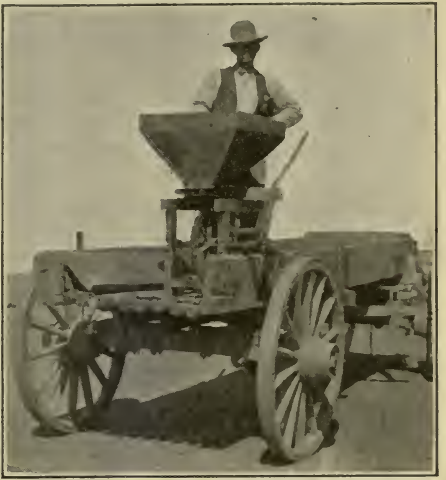

FIG. 21.—Sowing poisoned-bran bait for grasshoppers by means of a broadcast grain seeder. (Webster.)

SUMMARY OF CONTROL MEASURES.

1. The most important and by far the most practicable means of controlling grasshoppers is by the application of the poisoned baits described on pages 15 and 16 of this bulletin. A strong effort should be made to apply these remedies when the grasshoppers are young, thus saving labor and material and therefore money. In the semiarid climates the baits should be applied during the late afternoon hours and should have water added to them as mentioned above. In moist climates, such as obtain in the Eastern and Southern States, the baits may be prepared without the additional water and applied during the early morning hours.

2. Where the topography of the infested fields will permit, the use of hopperdozers or other grasshopper traps is sometimes partially effective, but these methods are not often wholly satisfactory.

3. The destruction of eggs by fall plowing, or disking, and harrowing is recommended where practicable.

4. If the best results are to be obtained, the cooperation of communities is essential.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. | 748 | JULY 22, 1916

Contribution from the Bureau of Animal Industry, A. D. Melvin, Chief.

A SIMPLE STEAM STERILIZER FOR FARM DAIRY UTENSILS.

By S. HENRY AYERS, *Bacteriologist*, and GEORGE B. TAYLOR, *Market Milk Specialist, Dairy Division.*

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NECESSITY OF STERILIZING DAIRY UTENSILS.

Cleanliness of dairy utensils is highly essential for the production of a high quality of dairy products, particularly milk and cream. The ordinary process of washing dairy utensils is not sufficient to assure freedom from infection and contamination, therefore sterilization is necessary.

Dairy utensils on small farms are not often efficiently sterilized, because steam is not available. The sterilizers now in use require a small boiler, and the whole sterilizing outfit is often regarded as too expensive for use, especially on farms where only a few cows are milked.

The object of this bulletin is to describe a simple and inexpensive yet efficient steam sterilizer which can be provided at a cost of from $5 to $10. It is believed that the sterilizer described here is cheap enough to justify its use on any farm from which milk or cream is sold. The additional keeping quality which the sterilization of utensils will give milk and cream will probably pay for the cost of the sterilizer in one season.

Dirty dairy utensils, and even those which apparently are clean but which have not been sterilized, contain vast numbers of bacteria which are added to milk or cream when it comes into contact with them. These bacteria when introduced into milk begin to grow and produce changes which spoil it. It is true that even when milk is produced under clean conditions it will contain a few bacteria, and when such milk is placed in unsterilized utensils or is run through an unsterilized strainer cloth or separator, large numbers of bacteria are added, which are liable to spoil it quickly.

When dairy utensils are sterilized by steam, all bacteria and disease germs which may be upon them are destroyed and therefore milk and cream when placed in these utensils will keep sweet much longer.

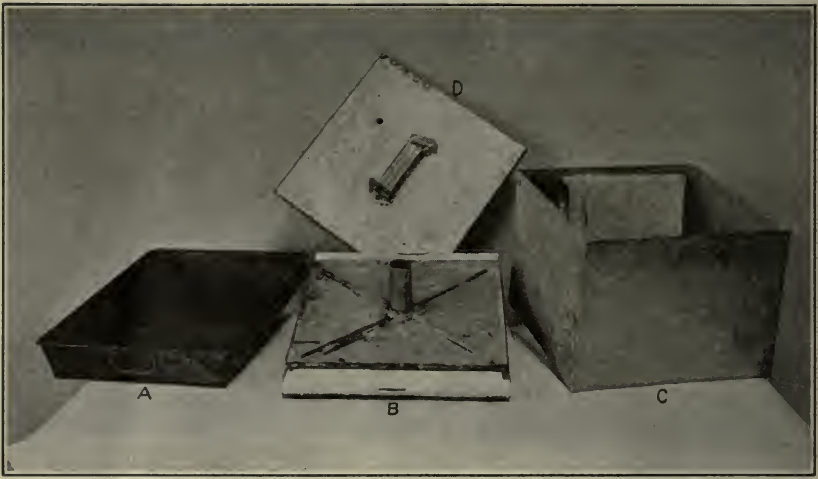

FIG. 1.—Parts of the steam sterilizer. A, roasting pan; B, cover of pan; C, galvanized-iron box; D, cover of box.

CONSTRUCTION OF THE STERILIZER.

The sterilizer herein described and recommended to the farmer is designed to be of greatest use to those who have one, two, or three 10-gallon or smaller cans with a similar number of pails and a strainer cloth. It can be used, however, with a larger number of cans.

The sterilizer consists of the parts shown in figure 1. First is a roasting pan (A) of standard size, 20 inches long, 14 inches wide, top measurement, and 3 inches deep. The cover is in three parts; the lower part, fitting closely over the pan, is covered with asbestos, upon which is placed the upper part, the latter being the same width as the pan but 3 inches shorter at each end. It is made as follows: Take a sheet of heavy galvanized iron and cut it large enough to cover the top of the roasting pan, allowing a little to overlap the edge. Solder flanges beneath this cover so that they will meet the edge of the pan, thus making a tight cover. Then cut a hole in the center of the cover 1½ inches in diameter and solder on a round, galvanized-iron pipe 4½ inches in height and 1½ inches in diameter. The cover should then be insulated by covering with a piece of asbestos board five-sixteenths of an inch thick; a hole should be cut in the center of this piece to allow the steam outlet pipe to pass through. Then for the upper part make a shallow pan of galvanized iron 14 inches square with sides five-eighths of an inch high; cut a hole 1½ inches in diameter and fit the pan on top of the asbestos, allowing the steam outlet pipe to extend through the center hole. When the pan is pressed down closely to the asbestos, solder it to the steam outlet pipe which passes through it. On the pan four strips of stiff galvanized iron three-eighths of an inch wide are soldered. These should extend three-eighths of an inch above the bottom of the pan, as shown in figure 1, and should run from a distance of 1 inch from the corners to 1 inch from the steam outlet in the center. A section through the cover (B) is shown in figure 2.

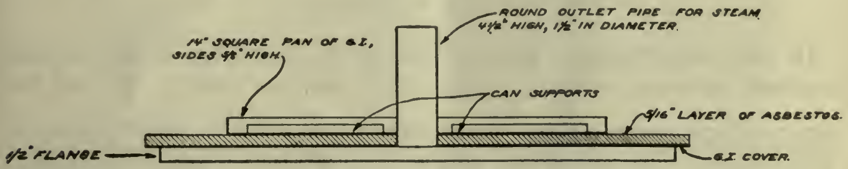
ROUND OUTLET PIPE FOR STEAM 4½" HIGH, 1½" IN DIAMETER.
14" SQUARE PAN OF G.I., SIDES ⅝" HIGH.
CAN SUPPORTS
5/16" LAYER OF ASBESTOS.
½" FLANGE
G.I. COVER.

FIG. 2.—Section through cover of roasting pan.

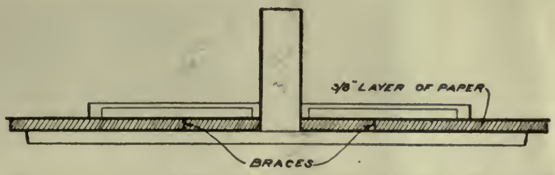

FIG. 3.—Section through galvanized-iron cover, showing paper insulation.

In case asbestos can not be obtained, paper may be used instead. Pack papers tightly to a height of three-eighths of an inch over galvanized iron and cover with another iron sheet, soldering all edges together to make absolutely tight seams. This will form an insulated cover three-eighths of an inch thick which will replace the asbestos. A cross section through this type of cover is shown in figure 3. The construction is very similar to that shown in figure 2. The rest of the sterilizer, seen in figure 1, consists of a galvanized-iron box (C) with a removable cover (D) which has a handle on the top. This box has no bottom, the 14-inch shallow pan on the asbestos over the cover of the roasting pan forming the base of the box. The sides should be made separate and should be 11 inches high. These sides should fit tightly into the shallow pan just mentioned. On one side of the box at the top a wire should be attached three-fourths of an inch from the top and one-half inch from the side. This is shown in figure 1, where a strainer cloth may be seen hanging. The cover of the box (D) should be made large enough to extend over the sides and fit closely.

SOURCE OF HEAT.

In the department's tests of the outfit described a two-burner wickless kerosene stove was used with excellent results. To get the full heating effect, however, it was found necessary to raise the burners until their extreme top was within seven-eighths of an inch from the bottom of the pan, which should rest on the stove grating. This change should be made in case it is found impossible to raise the steam to a temperature of 210° to 211° F., as the best results are obtained with steam at that temperature. The burners can be raised easily at little expense.

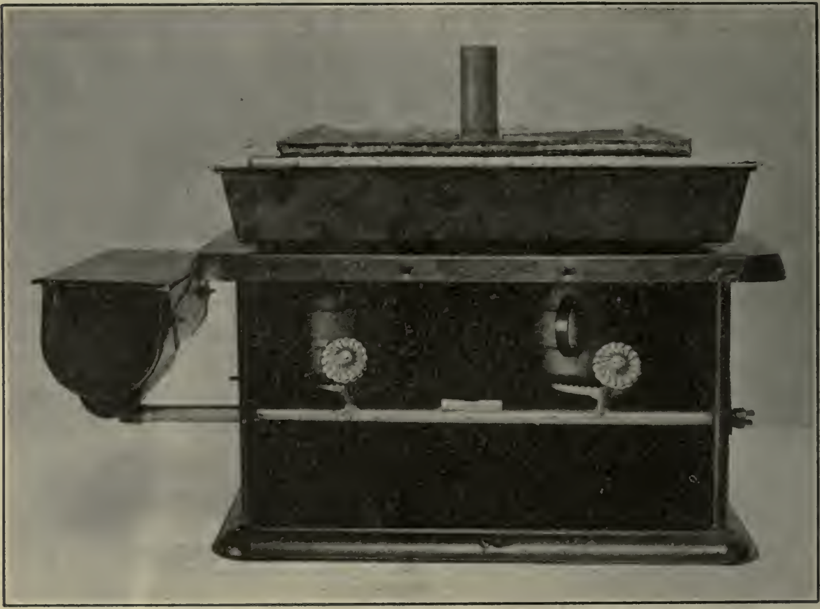

FIG. 4.—Sterilizer in position on oil stove to sterilize cans and pails.

The sterilizer, however, may be placed on the kitchen stove or over any other source of heat, such as a gas, gasoline, or laundry stove which burns either wood or coal. It is necessary, however, to have sufficient heat to furnish steam at the end of the outlet pipe at least 205° F., and 210° to 211° F. should be obtained if possible.

COST OF STERILIZER.

The cost of the sterilizer itself should not be more than $5. The roasting pan varies in price from 25 cents to $1, depending on the grade of iron. The galvanized iron, with asbestos and construction work, should not cost more than $4, and the work can be done by any tinner. A two-burner wickless kerosene stove costs from $3.50 to $4.50 but in many cases it will not be necessary to purchase a stove.

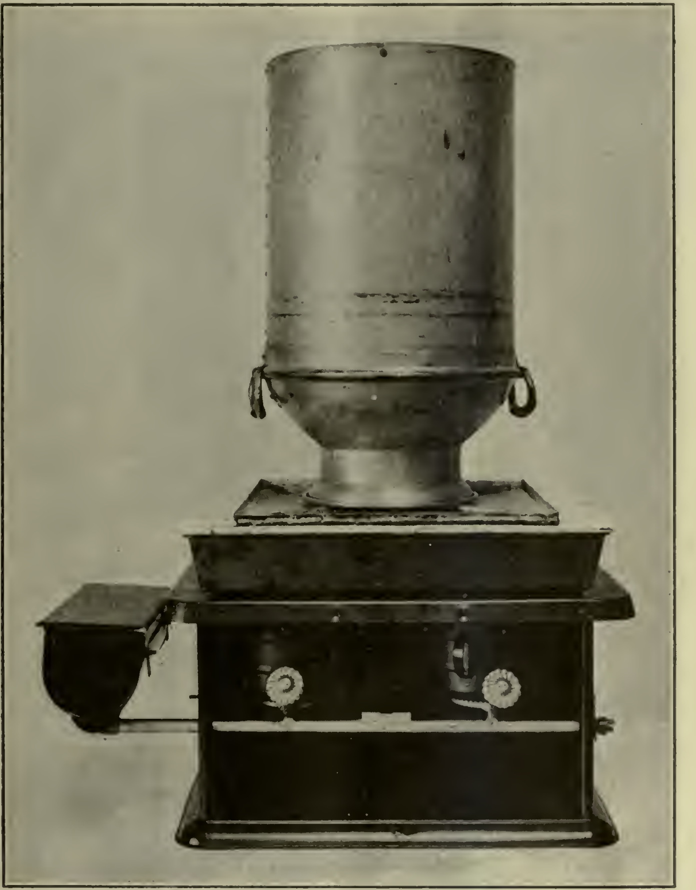

FIG. 5.—Can in position for sterilization.

METHOD OF OPERATING THE STERILIZER.

TO STERILIZE CANS.

Fill the roasting pan with water to a depth of 1 inch. Fit the cover on the pan and place on a two-burner kerosene stove, as shown in figure 4. As soon as the water heats sufficiently, steam will come from the outlet pipe. The temperature of the steam at its first appearance is about 140° F. Continue the heating until the temperature of the steam at the end of the outlet pipe is at least 205° F.; this should be determined by a thermometer. When the steam has reached this temperature, place the can inverted over the steam outlet, as shown in figure 5, for five minutes, then remove, shake out any water, and place upright on the floor. The can should be absolutely dry in one or two minutes. If not dry in that time it shows that the steam was not at 205° F. or above, or that the can had not been washed clean. On account of being so highly heated by the steam the can should dry almost immediately.

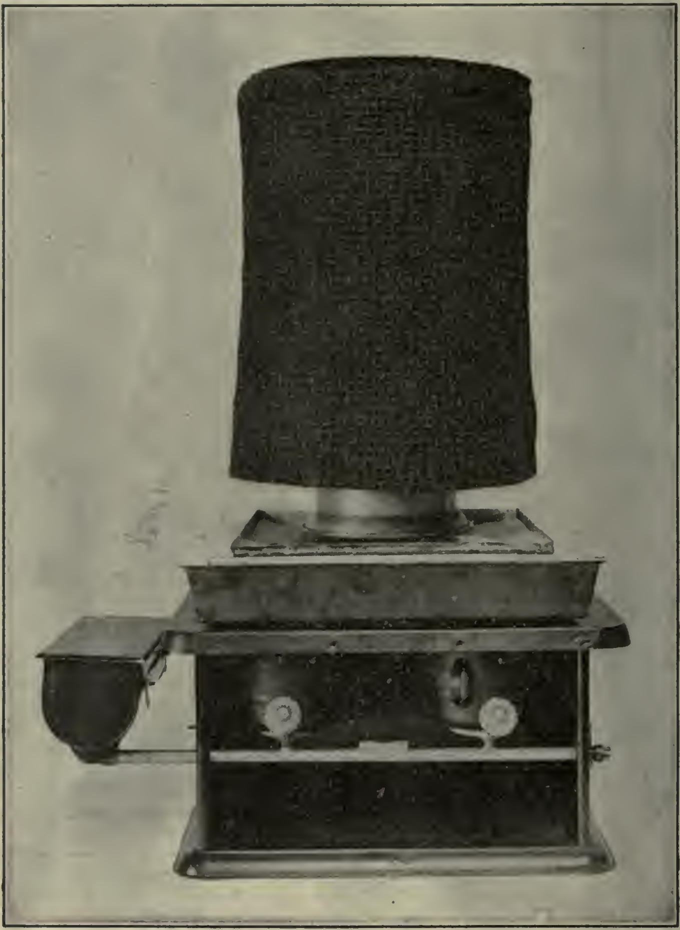

FIG. 6.—A form of insulating cover for cans.

In figure 6 an insulating cover is shown over the can. A similar cover can be made cheaply from a blanket, and its use is urged, especially in cold rooms, since otherwise the can may be cooled so quickly that it will not dry thoroughly.

TO STERILIZE PAILS.

See that the steam is at a temperature of 205° F. or above, then place the pail inverted over the steam outlet, as shown in figure 7. Allow it to remain five minutes, then remove, shake out the water resulting from the condensed steam, and set upright on the floor. The pails do not dry so quickly as the cans, but they will be absolutely dry within a few minutes. An insulating woolen cover is also recommended for use in a cold room. After the pails have been steamed and are dry, place them upright in a clean, dry, covered wooden or metal box until milking time.

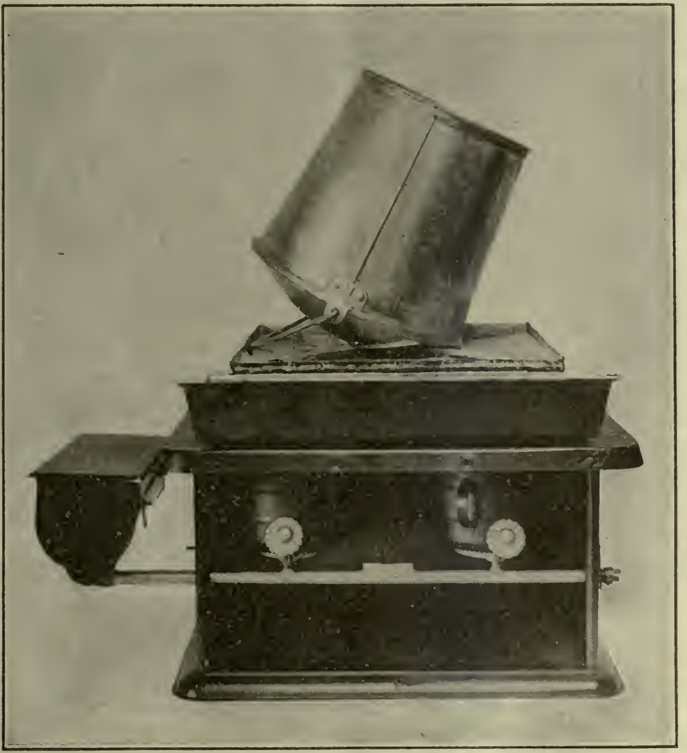

FIG. 7.—Milk pail in position for sterilization.

TO STERILIZE CAN COVERS AND STRAINER CLOTHS.

Use the box shown in figure 1. Before placing it in position, hang the strainer cloth on the wire at top of box, as shown in the figure, having the cloth so folded that one edge may be easily reached without handling the entire cloth. Have the steam at 205° F. or above, and place the box in position as shown in figure 8, leaving the cover off. Set the can covers upright along the sides of the box inside, with the tops of the covers against the sides of the box. As one side is covered by the strainer cloth there is space against the other three sides, giving room for at least three can covers. Place the cover on the box and steam for five minutes. Then remove the cover and take out the can covers, handling only the top edge. Shake out any water collected in the covers and place them, top down, on a table. It is important to observe this, so that the inside of the cover is uppermost. These covers will dry within two or three minutes, after which they should be placed tightly on the dry cans. Handle only the edge of the cover which remains outside of the can. The strainer cloth should remain hanging in place with the cover on the box until it is to be used at milking time.

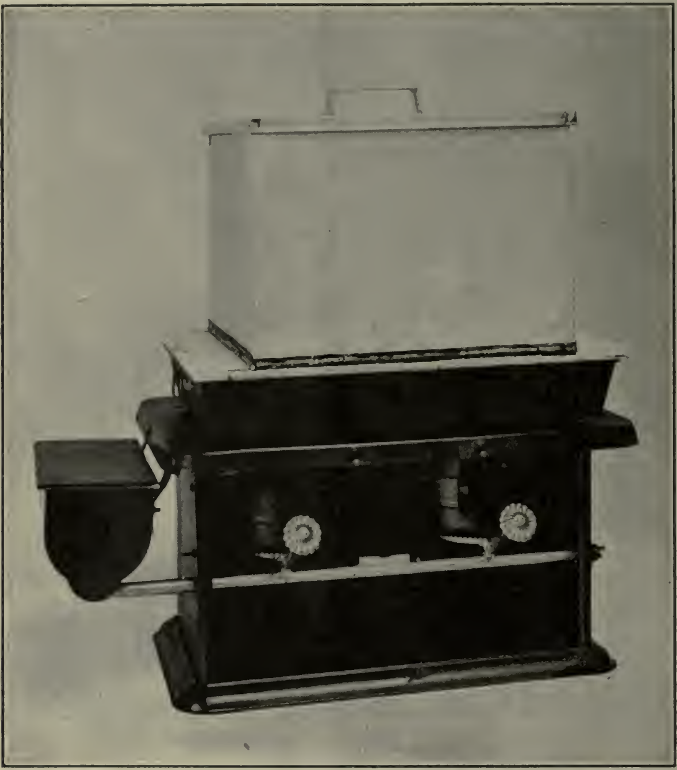

FIG. 8.—Box in position for sterilizing can covers and strainer cloth.

TO STERILIZE SEPARATOR PARTS.

The milk-receiving tank of the separator, the same as a milk pail, should be steamed five minutes while inverted over the steam outlet pipe. For other separator parts, use the box the same as for can covers. Wash the parts thoroughly and when the temperature of the steam is 205° F. or above, place the box in position as shown in figure 7. Place the separator parts in the box and put the cover on. Allow to remain for five minutes. If the parts are too large for the box, a special case should be constructed. After steaming, keep the tank and separator parts in a clean place free from dust.

COST OF OPERATION.

The cost of operation for the sterilization of two 10-gallon cans, with tops, two pails, and strainer cloth, using kerosene at 10 cents a gallon, will be about eight-tenths of a cent. This cost is based on the following figures: Each burner consumes one-half pint of oil an hour, making a total of 1 pint of kerosene, which at 10 cents a gallon amounts to 1¼ cents for fuel per hour. Starting with water at a temperature of 60° F. and with the water 1 inch deep in the roasting pan, about 12 minutes is required to heat the water and generate steam at a temperature of 205° F. Five minutes is then required for each can, the same for each pail, and the same for covers and strainer cloths. Thus the 2 cans require 10 minutes, the 2 pails the same, and the covers and strainer 5 minutes, making a total of 25 minutes, which added to the 12 minutes required to generate steam, makes a total of 37 minutes for the operation. In this operation no time has been allowed for changing utensils. Two minutes should be sufficient for these changes. To sterilize three cans with covers and strainers would therefore cost about 1 cent. When the sterilizer is used on the kitchen stove the cost should, of course, be very much less, if the stove were already in daily use.

RESULTS OBTAINED BY STERILIZATION.

When properly operated this sterilizer destroys practically all the bacteria in the utensils, including all disease germs which may be present. It will accomplish the same results as any sterilizer in which steam not under pressure is used. Experiments with this sterilizer show that the 5-minute steaming is, for practical purposes, as good as the 15 to 30 minute steaming usually recommended.

POINTS TO REMEMBER.

1. Rinse utensils in cold water, then wash thoroughly with hot water and washing powder. Utensils must be washed clean before sterilization. Sterilization is not a substitute for washing.

2. One inch of water in the roasting pan will furnish steam at a temperature of 211° F. for about 50 minutes. If the sterilizer is

operated for a longer period, water should be added to make up for loss by evaporation.

3. The temperature of the steam as it comes from the outlet pipe must be at least 205° F. and preferably 210° to 211° F.

4. Cans, pails, covers, and strainer cloths must be steamed for a full 5-minute period. Longer steaming will do no harm, but is not necessary. The 5-minute period must be reckoned from the time the can is placed inverted over the steam outlet, and the steam must be at least 205° F. when the can is placed in position.

5. An accurate thermometer, with a scale reading to 212° F., is necessary to determine the temperature.

6. When a can or pail is placed over the steam outlet its top should rest on the four raised metal supports in order to keep it three-eighths of an inch above the surface of the pan. This is necessary to prevent the water from the condensed steam from sealing the opening below the can or pail. If this space is filled with water, steam will not enter the can.

7. No arrangement is provided for the water from condensed steam to run back into the roasting pan. This can be arranged if found desirable. When only a few utensils are to be sterilized the water can be soaked up with a towel if the quantity has become too great, or the whole cover may be lifted and the water allowed to run off.

8. Some form of insulation is recommended for use over utensils which are being sterilized in a cold room. A blanket easily can be made for this purpose. This is desirable in order to keep the cans or pails hot long enough after sterilization to dry out quickly.

9. Cans should be dry in one or two minutes after removal when placed upright. If they do not dry within that time, they have not been sufficiently heated or were not washed clean.

10. The drying of dairy utensils after washing and sterilization is extremely important, for bacteria may develop in a moist can.

11. After the utensils are sterilized and dried, they should be placed in a room free from dust and should not be touched until milk is placed in them. Pails after steaming and drying should be placed upright in a clean, dry, covered wooden or metal box, where they should remain until milking time.

12. The sterilizer has been designed with the intent of making it both cheap and simple, to give the desired results. Satisfactory results should follow its use.

13. When using a kerosene or gasoline stove the sterilizing should be done in a room where milk is not handled, as the milk may absorb the odor of the oil.

14. The sterilizer may be used advantageously for separator parts, which should be steamed in the box used for can tops. In case they do not fit, a special metal box should be made.

15. After use, the parts of the sterilizer, especially the roasting pan and cover, should be cleaned and wiped dry, to prevent rusting.

16. The sterilization of dairy utensils is a matter of very great importance, and producers are urged, for their own advantage, to prevent the introduction of vast numbers of bacteria into their milk from unsterilized utensils which may look clean to the eye. Under ordinary circumstances bacteria grow rapidly in milk and spoil it, thereby causing losses to the producer and others.

The Dairy Division of the Bureau of Animal Industry, United States Department of Agriculture, will be glad at any time to answer questions regarding the construction and operation of this sterilizer.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO THE SANITARY PRODUCTION AND HANDLING OF MILK.

AVAILABLE FOR FREE DISTRIBUTION.

Care of Milk and Its Use in the Home. Farmers' Bulletin 413.
Bacteria in Milk. Farmers' Bulletin 490.
Production of Clean Milk. Farmers' Bulletin 602.

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Milk and Cream Contests. Department Bulletin 356. Price, 5 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 749 AUGUST 12, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

GRAINS FOR THE MONTANA DRY LANDS.

By N. C. DONALDSON,
Scientific Assistant, Office of Cereal Investigations.

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INTRODUCTION.

During the past 10 years the vacant lands of Montana have been rapidly settled. Much of the land has been homesteaded by people from other States. These settlers as a rule are not acquainted with farming conditions in Montana or with the crops to grow. As a result there is a constant demand for information regarding varieties of grain for the dry farms and how to grow them.

The purpose of this bulletin is to present the best available information regarding the varieties of grain to grow on the dry lands of Montana and the best methods of growing them. This information is based in part on tests conducted for the past eight years at the Judith Basin substation,[1] Moccasin, Mont. The substation is located in the center of the Judith Basin, in Fergus County, and in about the geographical center of the State. The crops that will be discussed are winter wheat, spring wheat, oats, barley, and flax.

THE DRY-LAND SECTIONS OF MONTANA.

In general the dry-land farming sections of Montana lie in the eastern two-thirds of the State. The western portion is mountainous, and comparatively little of the land is suitable for farming. The accompanying map (fig. 1) shows the location of the Judith Basin substation (Moccasin) and also gives the rainfall at a number of points in Montana.

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[1] The cereal experiments at this substation are conducted cooperatively by the State Agricultural Experiment Station of Montana and the Office of Cereal Investigations of the Bureau of Plant Industry. Persons interested should write to the Director of the Agricultural Experiment Station, Bozeman, Mont., for other publications on crops for Montana.

TOPOGRAPHY.

In general the dry lands of Montana are of two main types, the bench lands and the rolling hills. The bench lands are usually fairly level plains that lie above the river and creek bottoms and can not be irrigated. These lands may be broken to some extent by small creeks and coulees.

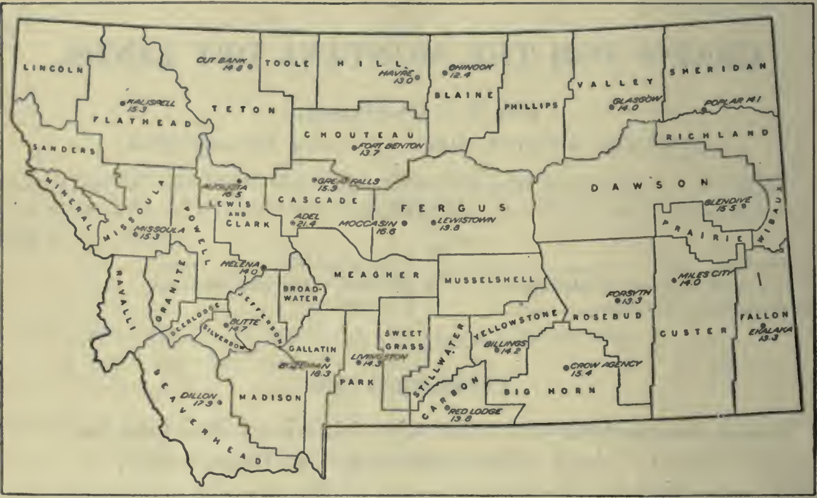

FIG. 1.—Map of Montana, showing the location of the Judith Basin substation (Moccasin) and of other points in the State. The figures indicate the average annual rainfall in inches. These averages for the most part are for 16 years (1898 to 1913).

The other type is characterized by gently rolling hills with small valleys between. Here the farming is usually done on the gentle slopes and in the valleys. This type of land is quite common in the extreme eastern part of the State, but is also found throughout all the dry-land districts.

SOIL.

The dry lands of Montana are mostly clay loam. They vary, however, from a heavy gumbo to a light sandy soil. The extremes of gumbo and light sand are not common. In the Judith Basin the general type is a rather heavy clay loam. Taken as a whole, the soils of the dry-land sections are well supplied with plant food. The depth of the soil varies in the different localities, although in most sections it is fairly deep.

CLIMATE.

There is considerable variation in the climatic conditions affecting crop growth in the different sections of Montana. In general, the extreme eastern part of the State has less rainfall, hotter summers, and a longer growing season than the central and western portions. Toward the western part of the State the rainfall gradually increases and the growing season is shorter.

RAINFALL.

Of all the physical factors that influence and control the growing of crops on the arid lands of Montana the rainfall and its distribution are the most important. About one-half the annual rainfall in Montana comes in April, May, June, and July, the months when it is of most benefit to the growing crops. This seasonal distribution is fully as important as the amount of the total rainfall.

The total annual rainfall varies from 13 inches at Glasgow in Dawson County to 21 inches at Adel in Cascade County. The average annual rainfall at Moccasin for the last 18 years was 16.6 inches. This is about the average for the Judith Basin but is a little higher than the rainfall in those sections of the dry-land area that lie east and north of the Judith Basin.

EVAPORATION.

Evaporation is another important physical factor that influences crop growth. It is in a way the measure of the usefulness of the rainfall. A section with a high rainfall and high evaporation may not grow any better crops than a section with less rainfall but low evaporation. The evaporation in Montana is lower than in the central and southern portions of the Great Plains. As a result it is possible to grow crops in Montana with less rainfall than in other sections where the evaporation is higher.

TEMPERATURE.

The temperatures in the various dry-land sections of Montana are variable. As a rule the summer temperatures are higher and there is more wind in the eastern part of the State than in the central and western portions. This is probably because the altitude is lower in the east and that section is farther removed from the influence of the mountains. Toward the mountains there is less variation in temperature but a shorter growing season. At Moccasin the average frost-free period is 116 days. This is about the average length of the growing season in the Judith Basin and other dry-land sections west of it at about the same altitude. To the north and east of the Judith Basin, where the altitude is lower, the frost-free period is longer.

DRY FARMING IN MONTANA.

It is only within the last 10 or 12 years that dry farming has been practiced in Montana. Previous to that time nearly all the crops grown were produced under irrigation, and the dry lands of the State were used for the pasturing of cattle and sheep. As more settlers began coming in, it was found that lands which were considered worthless for anything but pasture would produce good crops. With the opening of large areas to homestead entry the increase of dry farming was very rapid. At the present time much of the available land in Montana has been taken up and is rapidly being brought under cultivation.

CROPS GROWN.

Many new settlers in the State had very little capital with which to start. In many cases they were a long distance from market. It was natural, therefore, that they should grow a crop for which there was a ready cash market. The grain crops filled the bill. There is always a ready market for grains, especially wheat and flax. Their value is high in proportion to their bulk.

The average dry farmer when first starting has very few live stock. Crops are grown for market and not for feeding. As a result wheat and flax were the most important and in many cases the only crops grown. As the number of stock on farms increases, the production of feeding crops, such as oats and barley, also increases. No matter what system of farming is practiced, the cereal crops will always be important on the dry-land farms of Montana.

GROWING THE GRAIN CROPS.

The directions for growing cereals here given are general. Because of the variations in the soil and climatic conditions of the sections discussed, these directions may not apply in detail to all localities.

PREPARATION OF THE SEED BED ON SOD.

The best time to break the native sod is in April, May, and June. The work can be done most easily then because of the moist condition of the ground. A good job of breaking is shown in figure 2. If the grass is thick and the sod is tough, break 3½ to 4 inches deep; if the grass is thin and the sod is light, 6-inch to 7-inch plowing may be done. Follow the plow with either a roller or a disk to pack the sod and bring it in contact with the lower soil. This should be done the same day that the sod is turned. If the packing is done with a roller, which is the best method, follow with a disk harrow or a spike-tooth harrow to form a loose mulch on top.

If a spring crop is to be grown, sod land should be plowed early to allow early seeding. If winter wheat is to be grown, the plowing need not be so early, but the preparation should be the same in either case. In some sections it is the practice to plow the sod shallow and then backset, plowing 7 or 8 inches deep. This makes a good seed bed, but on account of the extra expense it is hardly to be recommended unless the farmer has plenty of horses and time.

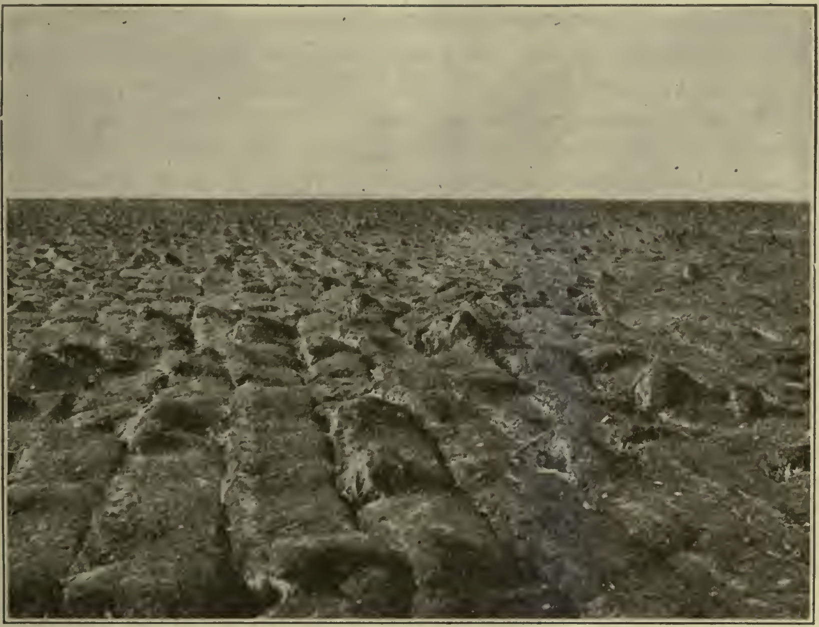

FIG. 2.—Sod land in the Judith Basin broken with the moldboard plow. The plow should have been followed with a heavy roller to flatten the furrow slice and bring it in contact with the moist subsoil.

PREPARATION OF THE SEED BED ON STUBBLE OR OLD LAND.

No definite rule can be laid down for the best time of plowing old land. This will depend upon the locality, the condition of the soil, and the other farm work. In the eastern part of the State, where the seasons are longer, it will often be possible to plow in the fall. Farther west there is seldom time after harvest to do much fall plowing. Plow when the land is in good condition and other farm work will permit. Plow 4 to 8 inches deep. Do a good, clean job, turning under all weeds, trash, and stubble. If the land is plowed in the spring, follow the plow with the disk and spike-tooth harrows. If in the fall, the ground may be left rough, to prevent blowing and to catch snow. The disk and spike-tooth harrows should then be used in preparing a seed bed the following spring.

A good seed bed should be firm underneath, with 2 or 3 inches of loose soil on top. This condition may be obtained by using the disk and spike-tooth harrows. Where spring grains are to be seeded on spring plowing, this work should be done immediately after the land is plowed. If the spring plowing is intended for winter grains, leave the surface of the soil rough until weeds and volunteer grains start. Then cultivate with disk and spike-tooth harrows. This will destroy the weeds and put the land in good tilth for fall seeding.

SUMMER FALLOW.

The practice of letting the ground lie idle through the summer every other year and keeping it free from weeds by clean cultivation is followed in most dry-land regions. The purpose of this summer fallow is to collect and conserve moisture for the crop that is to follow. This is an expensive practice. The land is plowed and cultivated, but no return is received from it that year. Summer fallowing can not be recommended as a general practice for the dry lands of Montana. Where winter wheat is to be grown on a large acreage it may be necessary to use this method to some extent. Where fallowing seems necessary it is more profitable to fallow every third year than every second year.

Land that is to be summer fallowed should not be plowed until weeds and volunteer grain have started growth. This will usually be in May and June. Turn under all the weeds, stubble, and trash. After plowing, do not cultivate enough to pulverize the soil. A rough mulch is better than a dust mulch. It will not blow or puddle. Keep the weeds down. The purpose of the fallow is to conserve moisture. Weeds use more moisture than is lost through evaporation. Cultivate when the weeds are small. Use a weeder that will not fine the soil too much.

The use of an intertilled crop, such as corn, is a profitable substitute for fallow. Corn is a profitable crop in a rotation for the average dry-land farmer of Montana. In most of the dry-land sections it will produce a good yield of grain, and it will always yield from 2 to 4 tons of fodder per acre. If the corn crop is cultivated and the weeds kept down, a good seed bed for small grain can be prepared by disking the corn stubble. Spring grains adapt themselves more readily to this method than winter grains. Where spring grains are to be sown, do not disk the corn land until spring, as the stubble will help to hold the snow. There is very little difference in the yields obtained from grains grown on fallow ground and grains sown on disked corn stubble. The latter method has the advantage of producing a profitable crop each year with but little more work than is necessary in the fallow system.

SELECTION OF SEED.

It pays to use good seed. Grow varieties that are adapted to your locality and conditions. Make sure that the seed is free from all weed seeds and from disease. This is important. Clean the seed well, blowing out all small and immature kernels and all trash. Every farmer should grow his own seed. He then knows what he is sowing and what results he can expect. By selecting seed from fields that are free from weeds and disease and that produce grain of the best quality, he can maintain and improve the quality of the grain he is sowing.

TREATING SEED FOR DISEASE.

Smut is probably the most common of the grain diseases in Montana. It is more often found in wheat than in any of the other grains. Smut can be fairly well controlled by treating the seed. The formaldehyde treatment is most commonly used for the stinking smut of wheat, oat smut, and the covered smut of barley. Mix 1 pound of 40 per cent formaldehyde (the ordinary commercial article, which can be purchased at almost any drug store) with 45 gallons of water. Place the grain in a pile several inches thick on a clean floor or canvas. Sprinkle the grain with the solution until every kernel is thoroughly wet. Cover this grain with sacks or a blanket for several hours. Then spread it out until it is dry.

The grain may also be treated in sacks. Place the solution in a barrel. Put a bushel to a bushel and a half of grain in each sack. Tie the sacks at the top, leaving plenty of room for the grain to swell. Soak the grain for 10 minutes in the solution. If the sacks are not too full, the grain will dry out in the sacks if they are set where the wind strikes them. Do not allow the grain to freeze while it is wet.

In treating grain, care should be taken to have the solution the right strength. If too weak it will not kill the spores. If too strong it will injure the grain. Be sure the formaldehyde you buy is full strength.

Wash out the drill with the formaldehyde solution. This will destroy any smut spores that may be in the drill.

For a more complete discussion of the smuts of grain and of smut treatments, see Farmers' Bulletin 507.

HARVESTING THE GRAIN CROP.

There are three general methods of harvesting the grain crops in Montana: (1) With combines, (2) with headers, and (3) with binders.

The use of combines (combined harvesters and thrashers) can not be recommended in Montana. When they are used the grain must be left standing until it is overripe. The weather in the autumn is likely to be unsettled. Rain and snow often fall before the grain can be cut. The quality of the grain that is left standing waiting for a combine is lowered by these storms. The grain is also likely to lodge, and part of it is then lost.

On the larger farms where most of the land is cropped to grain, cutting with a header (fig. 3) is the most practicable method. Fields cut with the header must be left until just about ripe. Grain can not be safely cut as green with the header as with the binder, but it can be cut greener than with the combine. Cutting grain with a header has the following advantages: The crop is removed from the land sooner than when it is bound and shocked, thus allowing more time to prepare the land for the next crop. In a dry year, when the straw is short, the grain can be cut easier and with less loss than with a binder. It makes possible earlier seeding on stubble land. More organic matter in the form of straw is returned to the soil. The expense of stacking headed grain is not so great as that of stacking bound grain. The quality of the grain is not injured by rain and snow, as may happen with standing grain awaiting the combine or grain in the shock. Thrashing can be done after the rush of the other farm work is over. The cost of thrashing is reduced.

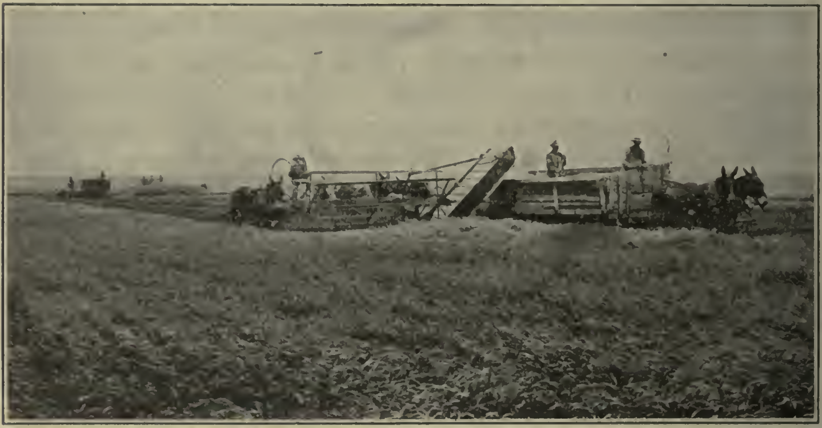

FIG. 3.—Harvesting wheat with a header. The headed wheat is being stacked in the center of the field to avoid long hauls with the header racks.

Grain cut with a header should be well stacked. Build a good, solid stack that will not blow over. Build it carefully with a smooth, rounded top and sides, so that it will turn rain and snow. On large fields it may pay to use a fork and derrick to do the stacking. The stacks should be so located as to avoid long hauls. Well-built stacks of headed grain are shown in figure 4.

If the grain is somewhat green or there are green spots in the field, arrange for circulation of air in the stack as follows: Make a platform 6 inches or a foot above the ground by placing small poles or boards across a couple of logs or timbers. Build the stack on this platform. A grain sack filled with hay or straw can be used to make an air hole from the bottom to the top of the stack. Place the sack in the center of the stack at the bottom. Build around the sack, pulling it up as the stack is built and keeping most of the sack above the level of the headed grain. When the stack is finished, pull out the sack and there will be an air space from the top to the bottom. This can be done at several places along the length of the stack. Grain stacked in this manner is less likely to heat or spoil even though it is somewhat green, for circulation of air through the stack is provided.

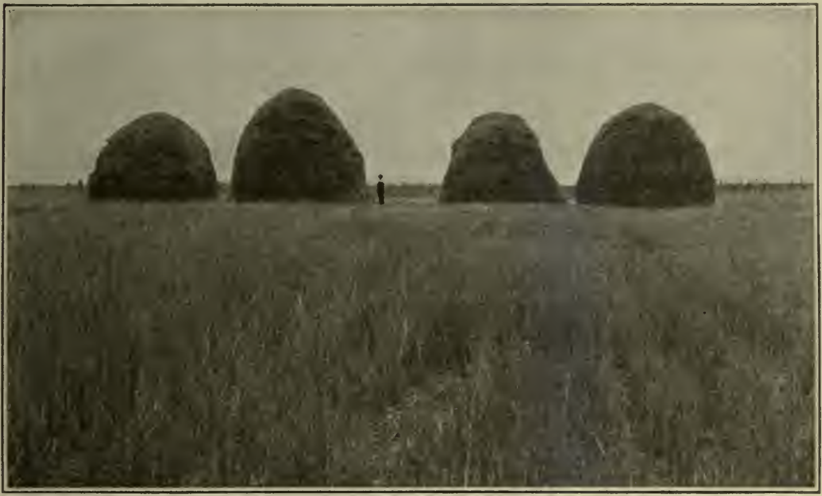

Fig. 4.—Well-built stacks of headed wheat.

For the smaller farms, where only part of the land is in grain, the binder is recommended. The binder does not cost as much as the header, nor does it require as many horses or men to operate it. For these reasons it is better adapted to the smaller farms, where the acreage of grain is comparatively small.

On the average-sized dry farm in Montana where diversified farming is practiced it will pay to stack the grain after it is cut with the binder. Where the farmer stacks his grain he is able to get on the land earlier and prepare it for the next crop. It is then possible to sow the following crop early, either in the fall or the spring. Early seeding is important for the successful growing of grain.

If the grain is stacked, it is not necessary to wait for a thrashing machine to come before working stubble land. Thrashing from the shock, as shown in figure 5, delays other work on the land. Grain that is stacked properly is not injured by rain and snow, like shocked grain. Stacked grain costs less to thrash than shocked grain. A smaller crew of men and teams is required. The total cost of stacking and thrashing may be more than the cost of thrashing from the shock, but all things considered it pays to stack. Grain thrashed from the stack sometimes commands a better price.

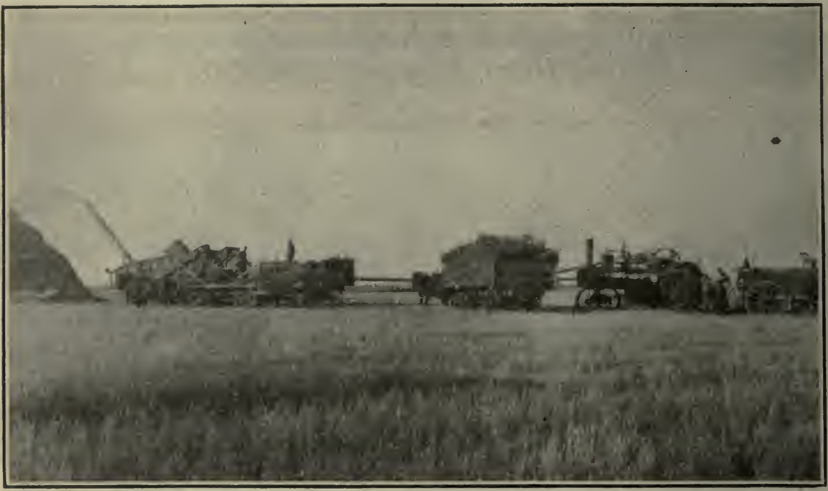

FIG. 5.—Thrashing wheat from the shock. Where wheat is thrashed in this way it is necessary to wait until a thrashing machine is available before the land can be prepared for the next crop.

GRAIN CROPS AND VARIETIES.

WHEAT.

Wheat is the most important dry-land grain crop in Montana. The climate and soil are favorable for the production of this crop, and there is always a ready market for it. It is primarily a cash crop, and for this reason will always be important on the dry farms of the State. The estimated total production of winter and spring wheat in Montana in 1915 was nearly 34,000,000 bushels. An excellent field of winter wheat in the Judith Basin is shown in figure 6.

WINTER WHEAT.

In 1915 the estimated production of winter wheat exceeded that of spring wheat by about 2,500,000 bushels. Winter wheat is not adapted to all of the dry lands of the State. In eastern Montana it is likely to winterkill. Good crops of winter wheat can be raised as far east as Forsyth, in Rosebud County. East of Forsyth it can hardly be recommended as a safe crop to grow, although it has been raised as far east as Glendive, in Dawson County. If winter wheat is to be grown this far east it should be sown in corn stubble. The cornstalks will help hold the snow and protect the wheat.

In 1915 the estimated production of winter wheat in Montana was 18,225,000 bushels. This was 7,162,000 bushels more than in 1914. This increased production is due largely to the increased acreage under cultivation, resulting from the high prices obtained for wheat in 1914.

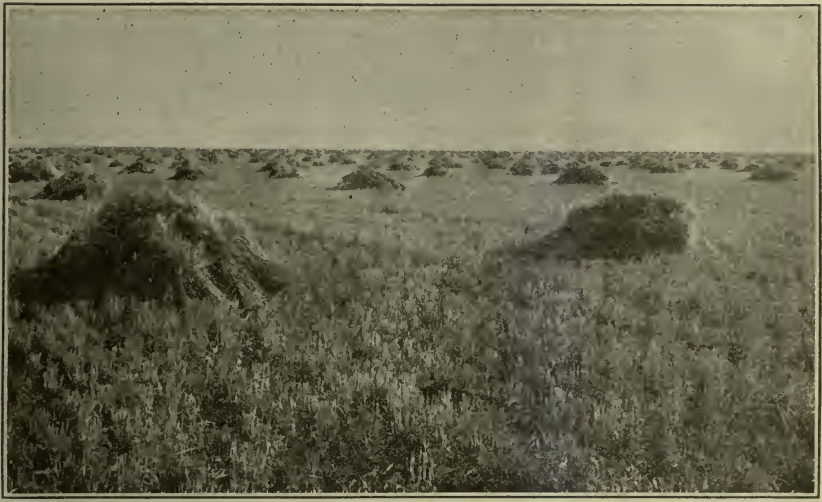

Fig. 6.—Winter wheat on breaking in the Judith Basin. This land was plowed in May and June and the wheat sown the following August. The average yield of the 112-acre field here shown was 35 bushels per acre.

VARIETIES TO GROW.

The winter-wheat variety most commonly grown is the Turkey. This wheat belongs to what is known as the Crimean group of hard red winter wheats. It was brought to this country by the Mennonites in 1873 from the Crimea, in southern Russia. Introductions of the Turkey and other related varieties have also been made by the United States Department of Agriculture at various times.

Experiments with varieties of winter wheat have been conducted since 1908 at the Judith Basin substation at Moccasin. A view of the field plats used in this test in 1915 is shown in figure 7. Of the winter wheats tested at Moccasin for seven years the Kharkof has given the highest yields. This variety belongs to the same group of wheats as the Turkey, from which it can not be distinguished. The Kharkof is a bearded wheat, with hard red kernels, which was imported by the United States Department of Agriculture in 1900 from Kharkof, Russia. It sells on the market for the same price as Turkey wheat and is equally valuable for milling purposes. It will stand more extreme heat and cold than the Turkey and is more drought resistant. Where it has been tried in Montana it has given higher yields than the Turkey. The Kharkof is recommended as the best winter wheat to grow on the dry lands of the State.

DATE AND RATE OF SEEDING.

It is important to seed winter wheat at the right time. The best time to sow varies somewhat in the different sections of the State. In the eastern part it will not be necessary to seed as early as farther west, where the seasons are shorter. Wheat should be sown early enough in the fall to get a good start before winter. Wheat that is seeded late is likely to winterkill. It is also later in maturing than early-sown wheat. Wheat that is seeded early often matures early enough to escape dry spells that injure late-sown wheat.

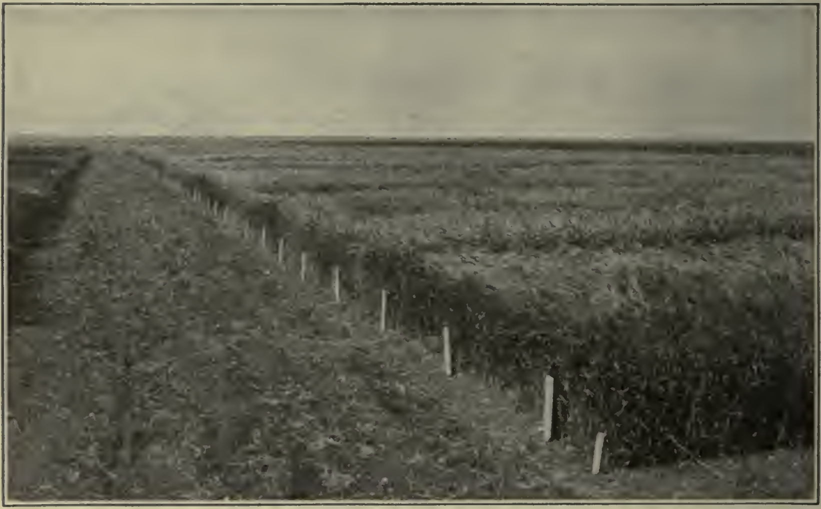

FIG. 7.—Field plats of winter wheat at the Judith Basin substation, Moccasin, Mont., in 1915.

The condition of the seed bed influences the time of seeding. There is no reason for late seeding on fallow ground, for it should always contain enough moisture to cause germination. On land from which a crop has recently been harvested there often is not enough moisture in the early fall to start the wheat. In this case it is better to wait until rain comes before seeding. After the crop is removed it is sometimes too dry to plow until after rains come. This will, of course, delay seeding.

In a six-year test at Moccasin the best results have been obtained by seeding winter wheat between August 10 and September 10. The exact date will vary for different years and for different localities. Seeding after the middle of September is risky. While in many cases the wheat will come through, the chances are just as good that it will winterkill. On the average, higher yields are obtained from the early seeding.

On a good seed bed, one that is firm underneath with 1 or 2 inches of loose soil on top, it is not necessary to seed more than 2 or 3 inches deep. The principal thing is to get the seed down to moist earth.

The best rate of seeding for winter wheat on dry land is 3 pecks per acre. This has been proved by experiments conducted at Moccasin and other points in the State. This is the rate used by most of the farmers in Montana. Since winter wheat tillers freely a good stand can be obtained with a light rate of seeding. Some farmers claim that 2 pecks is enough to seed. This may give good results in some years when the wheat is seeded early, but usually it will not give a thick enough stand. Thin stands allow the weeds to get a start and the yield is reduced. When wheat is seeded late it is best to sow 4 pecks per acre. Then if there is some winterkilling the stand will still be thick enough.

Every farmer should test his drill and know just how much it sows when set at a certain rate. A drill often becomes worn and seeds more or less than the indicator shows. If wheat that has been treated for smut is sown before it is thoroughly dry the drill should be tested with the swollen kernels and set to sow at the correct rate.

SPRING WHEAT.

Spring wheat is not as important a crop as winter wheat for the dry lands of Montana. It is most largely grown in the eastern sections of the State where winter wheat is not a sure crop. Spring wheat is more likely than winter wheat to be injured by dry weather and by frost. Experiments at Moccasin show that, on the average, the best winter wheat variety yields about 8 bushels more than the best spring wheat.

Because of its shorter growing season, spring wheat adapts itself more readily to a rotation system than winter wheat. It works in well where a cultivated crop like corn is grown as a substitute for fallow. Spring wheat on disked corn ground is one of the most profitable grain crops that can be grown on the dry lands of the State.

VARIETIES TO GROW.[1]

There are two main divisions of the hard spring wheats, the common and the durum (macaroni). These are quite distinct from each other. The durum varieties have broad heads with long, stiff beards. The common wheats have longer, rather slender heads, which may be either bearded or beardless. When bearded, the beards are not so long as those of the durum varieties. Heads of representative varieties of several groups of spring wheat are shown in figure 8.

At Moccasin in a seven-year test the durum wheats have yielded slightly more than the common wheats. Of 12 durum varieties which were tested the Pelissier has given the highest average yield. This variety has not yet been distributed to any great extent. It has hairless white chaff with black beards. The kernels are a little larger than those of most durum wheats and are a clear amber color. Other better known durum varieties that have yielded well are the Kubanka and Arnautka. These varieties have hairless yellow chaff and yellowish beards. The kernels are not quite as large as those of the Pelissier.

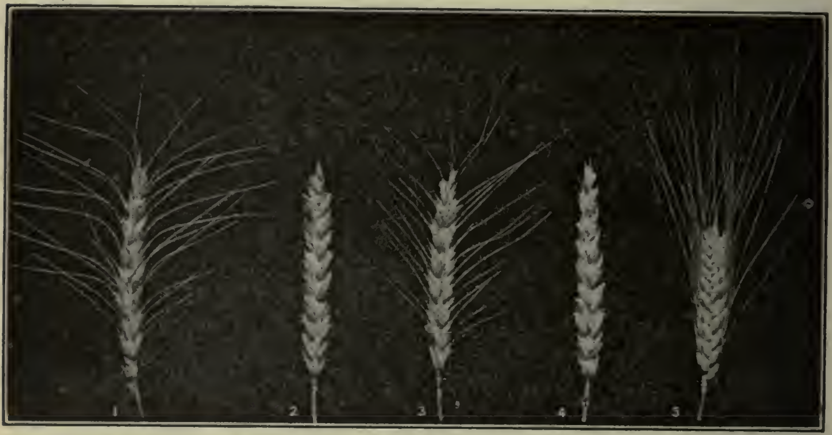

FIG. 8.—Representative heads of different types of wheat: 1, Turkey winter; 2, Fife; 3, Preston; 4, Bluestem; 5, durum.

Durum wheats are thought to be especially well adapted to the eastern portion of the State. Here the drought conditions are usually a little more severe than farther west. Good yields can be expected from durum wheats on all the dry lands of the State. While durum wheat often does not bring quite as much on the market as spring common wheat, the difference in price in the last few years has not been very great. Durum has sometimes sold for more than common wheat. The fear of a lower price for durum wheat should not stop the farmer from growing it, as the increase in yield usually will make up for any difference in price.

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[1] For a more complete discussion of spring wheat varieties, see Ball, Carleton R., and Clark, J. Allen, "Varieties of hard spring wheat," U. S. Dept. Agr., Farmers' Bulletin 680, 1915.

At Moccasin the yields of the spring common wheats as a whole have not been as high as those of the durums. Some good varieties, however, have yielded as high or higher than the durum varieties. Among these the Marquis is probably the most promising for the dry lands of Montana. This variety has been tested at Moccasin for only three years, but during that time it has yielded about the same as the Pelissier.

The Marquis is a hybrid wheat developed by the Canadian Department of Agriculture. It is beardless, with hairless white chaff. The kernels are short, plump, hard, and usually dark red in color. These characters place it in the Fife group of wheat. It is a good milling wheat and brings a good price. The yields obtained from the Marquis at Moccasin indicate that it is a good wheat for the dry lands of Montana. It is probable that it will be found better adapted to the western sections of the dry-land area. In the extreme eastern part of the State the durum varieties are recommended as being the best varieties to grow.

DATE AND RATE OF SEEDING.

No exact date can be given as the best time to sow spring wheat. This will vary in different years and in different localities. The important point to have in mind is that early seeding is best. Spring wheat should be sown as soon as soil and climatic conditions permit. Since fully half the annual rainfall comes in April, May, June, and July, it is important to have the wheat seeded early, so as to make the best use of this rainfall. Where spring wheat is seeded on corn stubble or fall plowing, early seeding is possible. If the land is weedy it is a good plan to let the weeds start and then cultivate to kill them before seeding the wheat.

At Moccasin the best results have been obtained by sowing the spring wheats at the rate of 4 pecks per acre. This is the rate used by most farmers and is 1 peck more than the usual rate for winter wheat. Where good seed is used, this rate will give a good stand. If the germination of the seed is poor it should be sown at a higher rate. Some of the larger seeded durum varieties should be sown at the rate of 5 pecks per acre.

In the spring there is usually plenty of moisture in the seed bed, so that it is not necessary to sow the seed more than 1 or 2 inches deep. Unless the surface of the seed bed is very dry do not seed deeper than this.

OATS.

The yields obtained from oats at Moccasin have been quite satisfactory. These results and the experience of farmers show that good yields of oats ordinarily can be obtained on the dry lands of Montana. At the present time the dry-land farmer does not grow oats as a cash crop but for feeding. As the stock on the farm is increased, oats will become a more important crop.

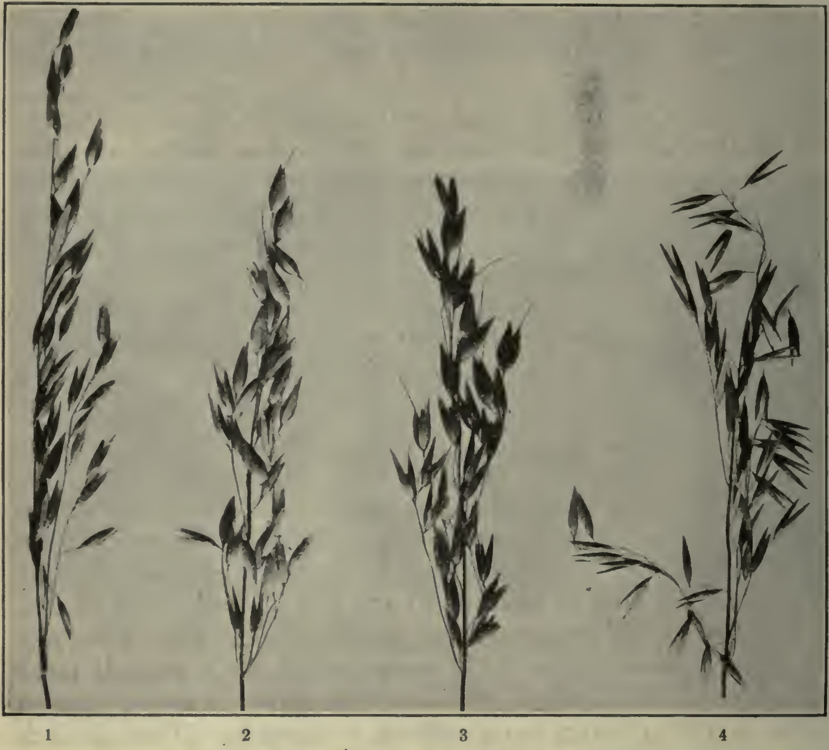

FIG. 9.—Representative heads of different types of oats: 1, White Russian; 2, Siberian; 3, Swedish Select; 4, Sixty-Day.

VARIETIES TO GROW.

The early varieties, such as the Sixty-Day and Kherson, are the best ones to grow. In a seven-year test at Moccasin the early varieties have exceeded the later ones, such as the Swedish Select, by about 16 bushels to the acre in average yield. Heads of the Swedish Select, Sixty-Day, and two other varieties are shown in figure 9. At Moccasin the Sixty-Day variety will mature in about 100 days from the time of sowing. This period will, of course, vary in different seasons and different localities. The Swedish Select and similar varieties are from 10 to 12 days later in maturing.

The Sixty-Day oat[1] was introduced from southwestern Russia into the United States by the United States Department of Agriculture in 1901. The Kherson is a very similar variety, also from Russia. At Moccasin it has not yielded quite as heavily as the Sixty-Day. The straw of these varieties is rather short and fine and the heads loose and spreading. The kernel is yellow in color, small, long, and rather slender. The hull is thin and under favorable conditions the weight per bushel is high. Objection to the Sixty-Day oats is sometimes made because of the small size and yellow color of the kernels. Since oats are grown for feed rather than for market, the yellow color is not objectionable. Tests have shown that the Sixty-Day has a smaller proportion of hull than most of the varieties with larger kernels. Thus a bushel of Sixty-Day oats has a higher feeding value than a bushel of large, thick-hulled oats.

The Sixty-Day variety, because of its fine straw, is better adapted to use for hay than some of the later varieties with coarse straw.

Wherever the Sixty-Day oat has been tried on the dry lands of the State it has given good results. It is recommended as being the best variety to grow on Montana dry farms.

DATE AND RATE OF SEEDING.

As with spring wheat, the best results are obtained from seeding oats early. While they do not require as long a growing period as spring wheat they should be seeded fully as early. Sow as soon as soil and climatic conditions permit. Have the seed bed well prepared. Do not sow the seed too deep; 1 to 2 inches should be deep enough to put the seed in moist soil.

Because of the small size of the grain, a lower rate of seeding is desirable for the Sixty-Day than for most varieties of oats. The best results have been obtained by seeding 4 to 5 pecks per acre.

BARLEY.

At the present time barley is not an important crop on the dry lands of Montana. Its chief value to the dry-land farmer is for feed. The best varieties of barley have produced very heavy yields at Moccasin, and it is believed that the crop should be much more extensively grown. In pounds of grain per acre barley has yielded more than any other grain under experiment.

There are two main groups of barley, the hulled and the naked, or hull-less. In both of these groups there are 2-rowed and 6-rowed and also bearded and beardless varieties. The hulled barleys are used for brewing and feeding purposes, while the hull-less varieties are used only for feeding. Heads of several of the important varieties of barley are shown in figure 10.

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[1] For a more complete discussion of this variety, see Warburton, C. W., "Sixty-Day and Kherson oats," U. S. Dept. Agr., Farmers' Bulletin 395. 1910.

VARIETIES TO GROW.

At Moccasin the highest yielding variety of barley has been the White Smyrna. This is a 2-rowed, bearded, hulled variety. It was obtained from Asia Minor by the United States Department of Agriculture. The head is of medium length and the kernels are large. The straw is rather short, especially in a dry season. The shortness of the straw is the main objection to the variety, but if sown early it will always grow tall enough to be cut with a binder.

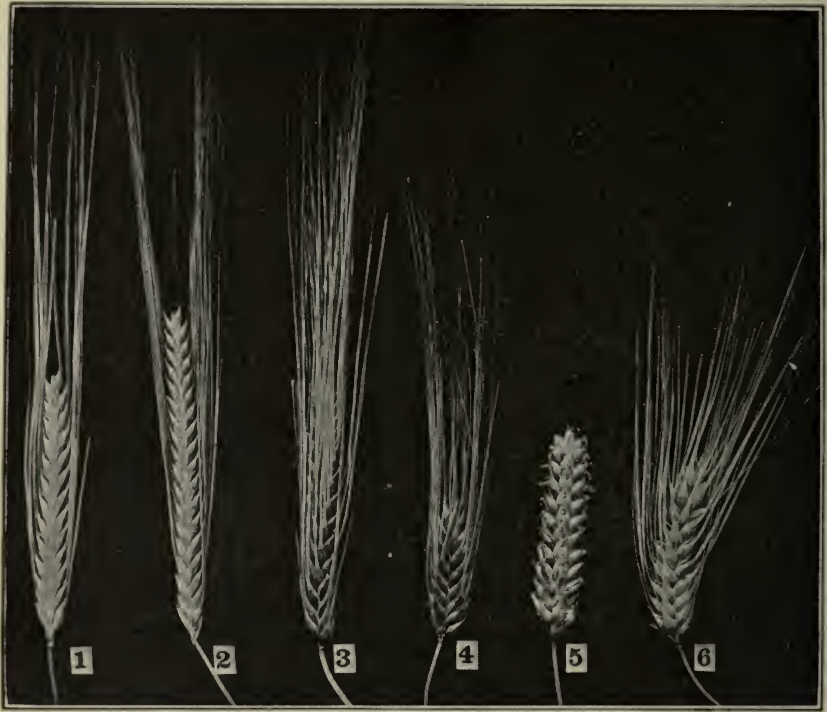

FIG. 10.—Representative heads of different types of barley; White Smyrna (1) and Hannchen (2), 2-rowed hulled varieties; Coast (3) and Mariout (4), 6-rowed hulled varieties; Nepal (5) and Himalaya (6), 6-rowed naked varieties.

The White Smyrna is the earliest of the barleys that have been grown at Moccasin. It matures about the same time as Sixty-Day oats. The length of its growing season varies from 95 to 105 days, depending upon the season and locality. In trials in other parts of the State excellent results have been obtained. The White Smyrna is recommended as being the best barley to grow under dry conditions in Montana. It seems especially adapted to regions where severe droughts are likely to occur.

At the present time the naked variety Nepal is probably the most commonly grown barley in Montana. This variety perhaps is better known as "White Hull-less" and is often called "goose wheat." It is a 6-rowed, hull-less, beardless variety. It has rather coarse straw and broad leaves. The heads have a tendency to break off when ripe and it is likely to lodge in a wet year. It is a little later in maturing than the White Smyrna and does not yield as well. Because of its coarse straw and broad leaves and the freedom from beards it is a very good variety to grow for hay. It is also a good grain to grow for hogging off. To farmers who want a grain for these purposes the Nepal (White Hull-less) barley is recommended.

DATE AND RATE OF SEEDING.

As with the other spring grains, early seeding is necessary to obtain good results with barley. The exact time to sow will, of course, depend upon local conditions. Where the seed bed is well prepared and free from weeds, sow as early as possible in the spring. If the seed bed is in poor tilth or weeds are plentiful it will pay to work the soil to make a smooth seed bed and destroy the weeds, even if seeding is somewhat delayed.

The best results are obtained from seeding the hulled varieties of barley at the rate of 5 pecks per acre and the naked or hull-less varieties at the rate of 4 pecks. The hulled varieties should be sown from the barley side of the drill and the naked varieties from the wheat side.

FLAX.[1]

Flax has been grown in Montana chiefly as a sod crop. Because of its high bushel value it is an important crop for the new settler who is a long distance from the railroad. Flax diseases increase in the soil when this crop is grown for several years on the same land; hence, it should be grown in rotation with other crops.

Flax yields at Moccasin have been satisfactory and show that a profitable yield can be produced on the dry lands of Montana. A view of the field plats used for the flax experiments at Moccasin in 1915 is shown in figure 11.

VARIETIES TO GROW.

The best yields in a 5-year test were produced by a variety known as the Russian. This variety belongs to the European seed-flax group. It is grown in North Dakota and has been distributed by the agricultural experiment station in that State as North Dakota No. 155. This Russian flax has yielded better at Moccasin than the wilt-resistant varieties distributed by the North Dakota station. In the eastern part of the State, where flax diseases are more common, the disease-resistant varieties may do better than the Russian. The Russian is recommended for the western portion of the dry-land sections.

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[1] For a more complete discussion of flax growing, see Circulars 22 and 40 of the Montana Agricultural College Experiment Station.

One of the great objections to flax is that it is likely to bring weeds with it. Because of the size and shape of the seed it is difficult to take out the weed seeds. As a result many weed seeds are often sown with the flax. The crop grows slowly early in the season and makes little shade, so that it is a poor weed fighter. For these reasons care should be used in selecting flax seed to make sure that it is free from all weed seeds. Bright, plump, clean seed is also more likely to be free from disease than poor, shrunken seed. If clean seed is sown on clean ground, flax that is free from weeds and disease may be grown.

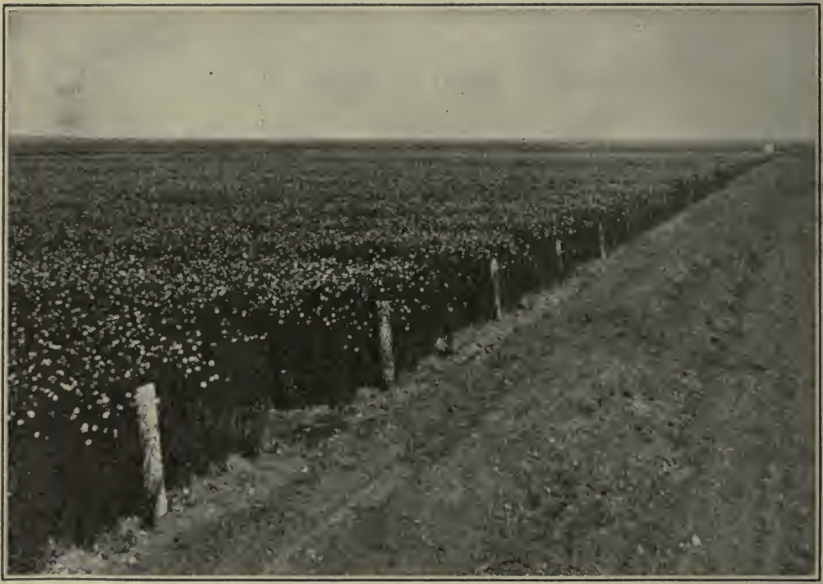

FIG. 11.—Field plats of varieties of flax at the Judith Basin substation, Moccasin, Mont., in 1915.

DATE AND RATE OF SEEDING.

The impression is rather general that flax should not be sown as early as the other spring grains. Experiments at Moccasin do not support this idea. In 1915 flax seeded at the same time as oats, wheat, and barley gave a higher yield than flax sown at a later date. While it is probably true that flax can not stand as much frost as the other spring grains, yet the best results at Moccasin have been obtained from flax sown between April 15 and May 1. Flax seeded after the latter date does not do as well. It is better to risk injury from frost in the spring than in the fall.

On a well-prepared seed bed 20 pounds of seed to the acre is enough. In the eastern part of the State even less seed may be desirable. Flax should not be sown too thinly, however, as too much space is left for weeds.

Flax requires a firm, even seed bed. It is important to have the surface of the seed bed smooth, so as to insure even germination and growth. Flax straw is short, and unless the seed bed is smooth and the growth even some of the crop is likely to be lost when it is harvested.

Do not sow flax too deep. The seeds are small and the young plant has difficulty in reaching the surface. Covering the seed to a depth of 1 or 1½ inches is sufficient.

SUMMARY.

The chief dry-farming districts of Montana are in the eastern two-thirds of the State.

There are two main types of dry-farmed land, the level benches and the rolling hills.

The soils vary from a heavy gumbo to a light, sandy loam. The great bulk of the soil is made up of various kinds of clay loams. All types are usually well supplied with plant food.

The rainfall varies from 13 inches in Dawson County to 21 inches in Cascade County.

Evaporation in Montana is lower than in the southern and central Great Plains area.

The frost-free period at Moccasin, in the central part of the State, is 116 days. It varies from 80 days in the western portion of the dry-farming district to 125 in the eastern.

The small grains are important for the dry-land settler, as there is always a ready market for them.

Native sod should be broken in April, May, or June, and the plow followed with some tool to pack the soil.

The time of plowing old land depends on the soil and climatic conditions and the need for doing other farm work.

Fall-plowed land should be left rough, to catch the snow and prevent the soil from blowing. Spring-plowed land for spring grains should be worked down immediately after plowing.

Summer fallowing is not recommended as a general practice for Montana. Where summer fallowing appears to be necessary, it may be done every third year instead of every second year. Do not plow summer fallow until weeds and volunteer grain have started.

Have a rough mulch instead of a dust mulch. Keep the weeds down by cultivating when they are small. Use a weeder that will not fine the soil too much.

Use a cultivated crop, such as corn, as a substitute for fallow. Grain seeded on disked corn ground yields nearly as well as grain on fallow.

Grow varieties adapted to your locality and conditions. Sow grain that is free from disease and weed seeds. To prevent smut, treat all grain with a formaldehyde solution before seeding.

The use of a combined harvester and thrasher is not recommended for Montana. On large areas use a header and stack the grain carefully. On small farms use a binder and stack the grain.

Winter wheat is the most important dry-land grain crop in Montana except in the eastern part of the State. The Kharkof is the best variety of winter wheat to grow.

Sow winter wheat at any time between August 10 and September 10 at the rate of 3 pecks per acre.

Durum wheat is better than spring common wheat for growing on the dry lands of Montana. The Pelissier is the highest yielding durum wheat at Moccasin.

Of the spring common wheats, the Marquis is a promising variety which is adapted to the western portion of the dry-land section.

The Sixty-Day variety of oats is the best one to grow on dry land.

The White Smyrna is the best barley to grow on the dry lands of the State. When a barley for hay or for hogging off is desired grow Nepal (White Hull-less).

The Russian (North Dakota No. 155) is the best variety of flax to grow. In the eastern part of the State some of the disease-resistant varieties may do better.

Early seeding is desirable for all spring-grain crops. Sow spring wheat, oats, and barley as early as the land can be prepared. The best date for sowing flax is between April 15 and May 1.

The best rates of seeding for the spring grain crops are as follows: Wheat, 4 pecks to the acre; oats, 4 to 5 pecks; hulled barley, 5 pecks; naked (hull-less) barley, 4 pecks; and flax, 15 to 20 pounds.

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UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 750 SEPTEMBER 26, 1916

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

ROSES FOR THE HOME.

By F. L. MULFORD,

Landscape Gardener, Office of Horticultural and Pomological Investigations.

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INTRODUCTION.

The rose has probably been cultivated as long as any ornamental plant, and it holds a warmer place in the hearts of the people than any other flower. From earliest times it has been a favorite. It has figured in the literature of all ages and all nations. People in all stations of life yield homage to its beauty of form and color and to its delicious fragrance. It is loved by poor and rich alike. It is grown in the dooryards of the least pretentious cottages, where often the occupants are stinted in food and raiment, as well as on the grounds of large estates, where abound the choicest things that money can buy. It is also grown in immense quantities under glass and is the most popular winter cut flower for all occasions. So deep a hold has it on the affections of the people that it is often spoken of as the "queen of flowers."

Wild roses abound in great variety over practically all the temperate regions of the earth. Man has taken advantage of this and

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NOTE.—This bulletin is of general interest to those who wish to grow roses for pleasure and for the beautification of their home grounds.

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has appropriated the most pleasing wild forms for his use. In addition, he has so modified and improved the wild sorts by breeding and selection that now there is a rose for every need. The present bulletin, however, will be restricted to a consideration of roses for the lawn and border, for the arbor and trellis, for cutting, and for other ornamental purposes.

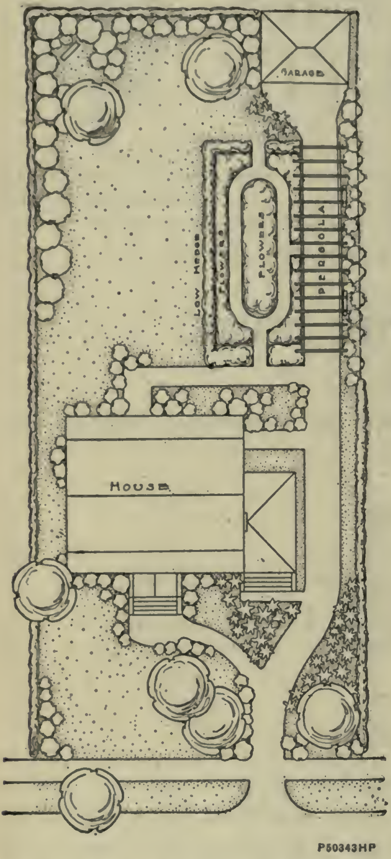

FIG. 1.—Plan for a city lot. Border roses may be used in combination with other shrubs in any of the clumps about the house or on the borders. Cut-flower roses would be appropriate in the garden or in the bed between the garden and the garage.

ROSES FOR THE LAWN AND BORDER.

Roses for the lawn and border are those which, because of their habits of growth and their foliage, are as well suited for use in relief planting about the ground line of buildings or in masses upon the lawn or along borders as other ornamental shrubs. When suitable sorts are chosen, roses are quite as appropriate and effective in mixed groups as are other shrubs. To be suitable for this use, however, they must be hardy, moderately free in growth, and possess foliage reasonably disease resistant and free from insect attack. In fact, for this purpose, foliage is more to be desired than fine flowers. The foliage is a feature during the whole growing season, while the flowers may cover a period less than a fortnight in length.

In figure 1 the groups on the borders of the grounds or about the base of the house might appropriately be partially composed of these hardy roses, while the cut-flower roses should be grown in the garden.

SPECIES AND VARIETIES.

Rugosa rose.—The Rugosa or Wrinkled Japanese rose[1] is one of the deservedly popular sorts for landscape planting. The original form, native to China, Chosen (Korea), and Japan, grows 5 to 6 feet tall, is rose colored, single, with rough, dark foliage. It blooms nearly all summer, and bears large bright red hips that persist during the winter. This rose is hardy in the North, succeeds well in the South, and thrives within reach of ocean spray. There is a good white form (fig. 2). Hybrids are being introduced that are more or less double and of several colors, from pure white to deep rose. Some of the hybrids are less prolific than the type in the number of hips formed.

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[1] *Rosa rugosa.*

Carolina rose.—The Carolina rose[1] is an upright shrub, native from Canada to the Gulf of Mexico and west to the Mississippi River; most common in moist places. It reaches a height of 8 feet, has dull green foliage, small pink flowers in flat-topped clusters, followed by small, bright-colored hips.

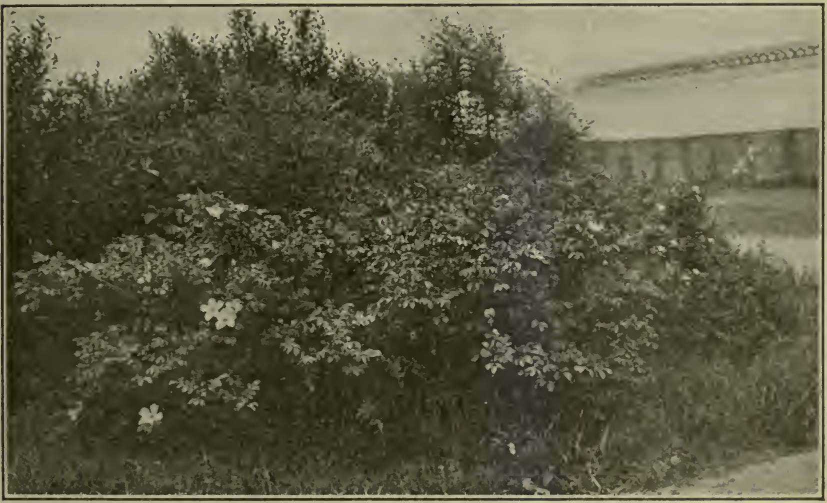

FIG. 2.—White Rugosa roses blooming in a clump of shrubbery. These roses bloom all summer and the blooms are followed by very attractive hips.

Rosa lucida.—The wild rose, native in New England, New York, and Pennsylvania, is a shrub growing 6 feet tall, with dark, shiny leaves. Its single pink flowers are borne singly or in small clusters in June and July. The hips are small, bright red. The stems are brownish red, showy, and attractive. When planted closely, it is especially desirable for a low ground cover 2 to 3 feet high. It effectually deters crosscutting and is good for rough banks and seaside planting or other adverse conditions.

Prairie rose.—The Prairie rose[2] is a shrub 6 feet high, with long, drooping branches that adapt it also for use as a pillar rose. Native from Canada to Florida and west to Wisconsin, Nebraska, and Texas, it is a hardy species, thriving under adverse conditions. Its flowers are scentless, single, deep rose, in several-flowered clusters, fading to almost white. The hips are bright red, showy, attractive, and persistent.

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[1] *Rosa carolina.*

[2] *Rosa setigera.*

Arkansas rose.—The Arkansas rose,[1] formerly included with *Rosa blanda*, is a valuable species, native from Minnesota and British Columbia to Mexico. Its flowers are single, pink, sometimes white, in clusters. It is useful for covering dry slopes and barren places. This rose is not widely listed by nurserymen, but it is a valuable sort for the dry regions in the western half of the country and for other dry soils.

Sweetbrier.—The sweetbrier, or eglantine,[2] is an upright, compact shrub from Europe that has run wild in many places. A characteristic spicy, aromatic odor is emitted by the young shoots in damp weather and from the leaves when bruised. The flowers are single, pink, one to three in a cluster; the hip is either orange or scarlet and the foliage is bright and glossy. There are many good crosses, among which are the Penzance hybrids.

Rosa eglanteria or Rosa lutea.—The Austrian Copper, Austrian Yellow, Persian Yellow, and Harrison's Yellow are important and useful varieties in the *Rosa eglanteria* or *Rosa lutea* groups. They are deep yellow, showy, with green or greenish winter stems. The Pernet rose is closely allied to these.

Dwarf Polyantha rose.—The Baby Rambler[3] roses comprise a group which includes a large number of varieties of dwarf habit (1 to 2 feet mostly), of many shades of white, pink, and red, with flowers borne freely in clusters throughout the season. They are very useful for low bedding.

Cabbage rose.—The Cabbage rose[4] is a shrub attaining a height of 5 feet which has only one blooming season, but that a long one. The flowers are double, either red or white. The variegated Provence rose is closely related. There are also cultivated forms with mossy calyxes, some with red flowers and some with white. There are other moss roses derived from hybrid perpetuals which are not adapted to the same uses as Cabbage roses.

Damask rose.—The Damask rose[5] is a round, compact, 5-foot shrub that holds its foliage late and bears two crops of red flowers.

Additional species.—In addition to the foregoing, and perhaps equally desirable, long lists of valuable species are offered by nurserymen, and many more are not yet in the trade. Among the latter, *Rosa hugonis* and *Rosa sericea* are very promising.

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[1] *Rosa arkansana.*

[2] *Rosa rubiginosa.*

[3] *Rosa polyantha.*

[4] *Rosa gallica centifolia.*

[5] *Rosa damascena.*

SOIL AND FERTILIZER.

The roses included in the foregoing descriptions are adapted to a wide range of soil conditions and may be counted on to succeed in any but extremely heavy or very sandy soils, and many of them will do well even on these types of soil. Thorough drainage and a plentiful supply of organic matter, with a reasonably constant water supply during the growing season, are essential. A soil capable of growing good garden or field crops is suitable for roses. The deeper the soil and the better the preparation at the beginning the more satisfactory will be the results.

Rotted cow manure is the best fertilizer. Any other well-rotted manure or good compost will serve the purpose. Fresh manure, especially horse manure, is to be avoided. If no other manure is available it may be used, but it must neither come in direct contact with the roots when planting, nor should it be used immediately beneath the plant in quantity sufficient to cut off direct connection with the subsoil and the water supply. Of the commercial fertilizers, ground bone is excellent to add as additional food, but will not answer as a substitute for plenty of compost. Where it is cheap enough, cottonseed meal may be used as a substitute for bone. Wood ashes are sometimes a helpful addition, or, when they are not available, lime and muriate of potash, applied separately, may be used. Sandy soils need more frequent applications of manure than heavier soils, as the organic matter burns out more rapidly in them and must therefore be replenished more liberally.

PLANTING.

The distance apart to plant will depend on the variety and also on the other plants used. The rose plants should be so spaced that when they reach maturity they will come together without overcrowding. Those of the Rugosa and the Austrian Copper groups should be planted 3 feet apart, the Baby Ramblers 2 feet, and the hybrid Rugosas and other kinds 4, 5, or 6 feet, depending on the vigor of growth of the variety.

Those varieties most used in landscape planting are usually priced by nurserymen according to size rather than age, that is, according to height and, to a certain extent, according to stockiness or weight. A short, stocky, or heavy plant is better than a taller light one.

The roses used as a substitute for other shrubbery are so hardy that they should be treated as other shrubs in their respective localities. In the extreme northern part of the United States and on the western Plains where there are strong drying winds in winter, early spring planting is best. In the other regions fall planting has advantages over spring planting, but not sufficient to warrant postponing spring planting until autumn, although enough to push planting in the fall rather than to wait until spring. These different areas are indicated on the map shown in figure 3. There are localities north of the line suggested as the division between successful fall and spring transplanting where fall planting can safely and satisfactorily be done, and others south of it where spring planting is more desirable. Spring planting should be done as soon as the ground is dry enough to work, or when it springs apart after being squeezed in the hand. Fall planting is best done as soon as the leaves have fallen from trees and bushes.

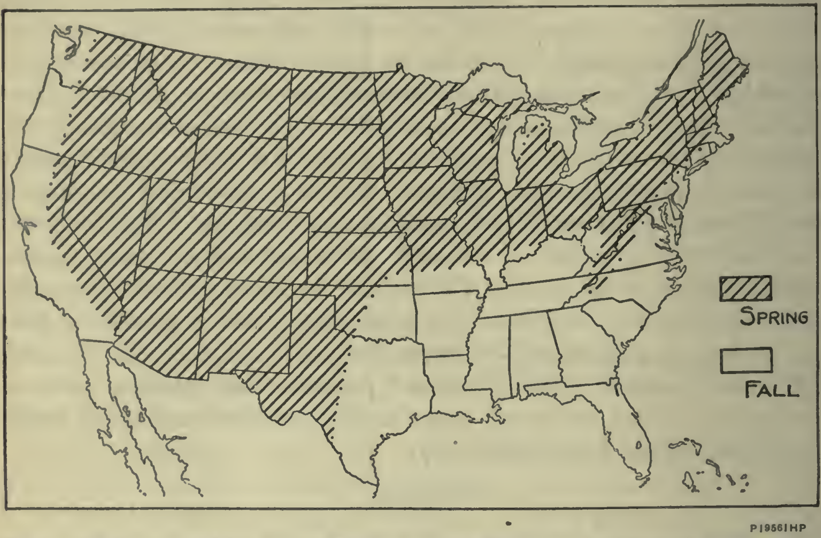

FIG. 3.—Outline map of the United States, showing the areas in which fall transplantings and spring transplantings of roses are usually most satisfactory.

Stock should be planted as soon as possible after it arrives. Sometimes it is impossible to do this immediately. In that case the plants should be unpacked and heeled in, that is, a trench should be dug, the roots laid in, and all brought in contact with the soil. With dormant plants it is usual to lay the tops close to the ground in this operation, though it is not essential. If the plant roots are dry when received, soaking them in water an hour or more before heeling in is desirable. If the stems are shriveled, burying the whole plant for a few days may restore plumpness and insure their growing. If the plants are frozen when received, they should be placed where they will thaw gradually, but they should not be unpacked until the frost is out beyond all question.

When ready to set, the plants should be taken to the permanent location, with the roots thoroughly covered, no matter how short the distance. More plants are killed by the undue exposure of roots at planting time than from any other cause. The roots may be placed in a bucket of water while removing to the planting ground and until planted, or they may be puddled in a mixture of thin clay and then be kept covered with wet burlap or other protection until planted, making sure the clay does not become dry before planting. They should be planted a little deeper than they were before. If planted too shallow the roots will probably be exposed, which means they would dry at the exposed part and thus prevent the passage of sap from the covered tips of the roots to the branches, or from lack of a firm anchorage winds would easily sway the plant, thereby loosening it in the soil, allowing the roots to dry and die. If planted too deep the bark of the buried stems would be injured, and growth would be checked until new roots formed nearer the surface. The proper depth for planting is shown in figure 4.

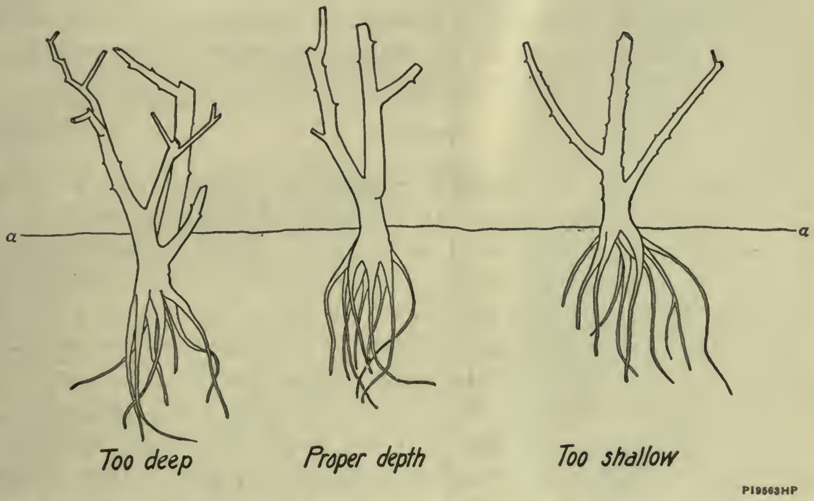

FIG. 4.—Sketches of rose bushes, showing proper and improper depths of planting. The line *a*—*a* indicates the surface of the soil.

In planting dormant bushes it is desirable to trim the ends of broken roots and any that are too long just before they are put into the hole, so that there will be good, smooth, fresh surfaces which can callus and heal over. It is usual to have this fresh-cut surface on the under side of the root. The hole in which the bush is to be planted should be several inches larger across than the roots will extend and ample in depth, with a little loose earth on the bottom. The roots should be separated well in all directions, with the soil well worked in among them, separating them into layers, each of which should be spread out like the fingers of the hand. When the hole is partially full, the plant should be shaken up and down so as to make sure it is in close contact with the soil under the crown where the roots branch. When the roots are well covered the soil should be firmed. This is best done by tramping. If the soil is in proper condition tramping can not injure the plants. This will leave a depression about them, but all the roots will be covered.

When all are planted, each one may be watered, although this is not usually necessary, especially if the roots have been puddled before planting. If water is applied, permit it to soak in about the roots and then fill the hole with dry earth without more tramping. With the soil wet from the watering it would be injurious to compact it more. If not watered the depression should be filled with loose earth the same as though it had been watered. After planting no watering should be done unless very dry weather follows, and even then care must be exercised not to overdo it till after growth starts. In watering, it is desirable to draw away some earth from about the bush, apply the water, and after it has soaked in draw dry earth about the plant again.

PRUNING.

Roses used as shrubs should be planted far enough apart to reach maturity without crowding. At the time of planting, one-half to two-thirds of the wood should be removed. Weak branches should be taken off, and long canes that would be liable to whip around and loosen the plant should be cut back. As far as practicable, pruning other than this should be accomplished by cutting out whole branches rather than by cutting off the ends. After the first year, pruning should consist of removing dead, dying, or weak wood, and crossing branches, including any that may be found with discolored pith. Cutting off the ends of branches should be avoided. Most of the roses suggested for border planting are improved by having the whole top cut off every 5 or 6 years. All pruning of these roses should be done in the spring, as summer or fall pruning would remove the hips prematurely and thus rob the plants of much of their attractiveness during the winter.

Only under extremely trying conditions do these roses need winter protection. If the autumn has been a dry one in the dry Plains region a good mulching after a thorough soaking of the soil should be given the first winter.

ROSES FOR THE ARBOR AND TRELLIS.

The climbing roses, used for covering pillars (fig. 5), porches, arbors, pergolas, summerhouses, terraces, walls, and fences will next be considered. Those which do not grow over 6 or 8 feet high are spoken of as pillar roses, while the more vigorous ones are called climbers, or ramblers, depending somewhat on their parentage. With a few exceptions, these roses have but one period of bloom, which lasts a week, or at most two weeks. The foliage must be depended upon for any ornamental effect during the remainder of the season; therefore, in those locations where an attractive appearance is desirable every day the first consideration is a rose with healthy, vigorous foliage not subject to disease and insect attacks. A healthy rose is especially attractive on or close to a house. Where shade is desired throughout the summer other climbers are often preferable to roses, as explained under the head of "Pruning" (p. 11.)

VARIETIES.

The varieties of climbing roses belong to several groups, with many intermediate kinds.

The Multiflora roses, usually spoken of as hardy climbers, are reasonably hardy in the North and are vigorous growers. They flower in clusters. Many of them are subject to mildew and insect attack. This is especially true of the so-called ramblers.

The Wichuraiana, or Memorial rose, has small, dark, glossy, almost evergreen foliage, which is resistant to disease and insects. Its blossoms are single, white, followed by bright hips. Many hybrids of this rose have been introduced, most of which retain the good foliage characteristic of the parent, while varying greatly in their blossoms. Bright hips, which persist through the winter, follow the blossoms on the single varieties.

The climbing teas are pillar roses and retain some of the tea habits, blooming more or less continuously throughout the season.

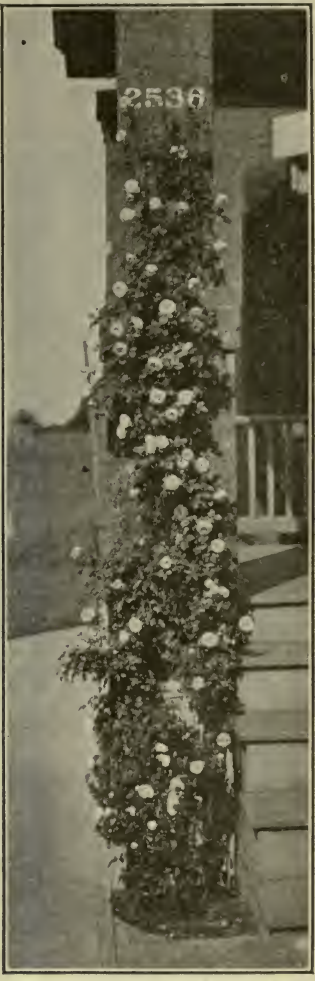

Fig. 5.—A young climbing rose (Clothilde Soupert).

Roses of the climbing Noisette group, represented by Marechal Niel, Lamarque, and other varieties, are suitable for culture only in the warmer sections where the winter temperature seldom falls to 10° F. above zero.

Roses of the Laevigata group, represented by the Cherokee, require as warm a climate as the Noisette roses.

SOIL AND PLANTING.

In planting climbing roses a good-sized hole should be dug and filled with good garden soil mixed with rotted manure. The body of good soil available for a climbing rose should be equal to a hole 3 feet square and 30 inches deep. The drainage must be good, as roses will not thrive where water stands about their roots.

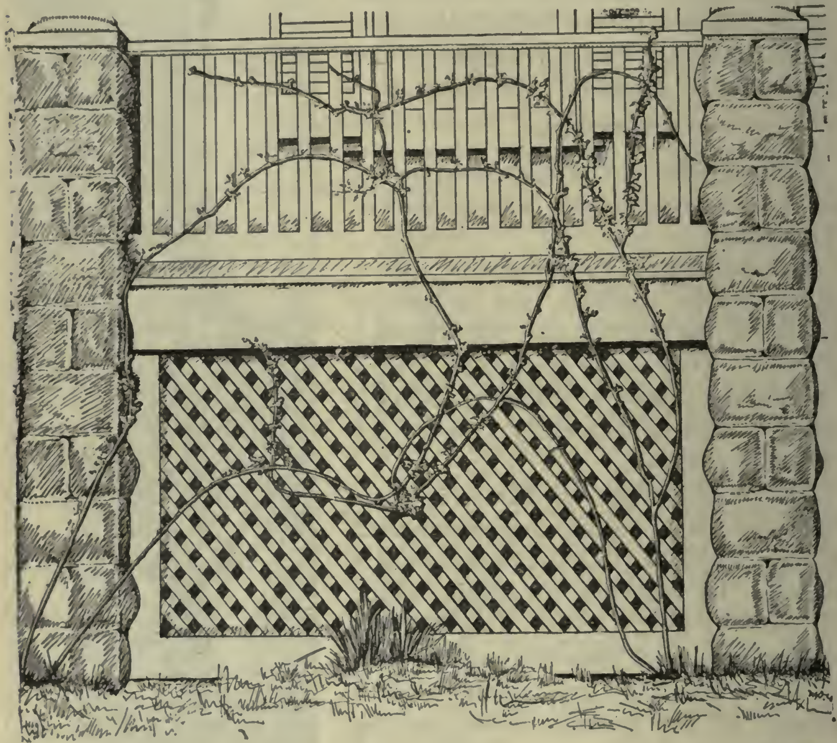

FIG. 6.—Climbing (Dorothy Perkins) roses after the spring pruning.

The planting must be done carefully, as already stated. One-half of the wood should be pruned off at planting time.

PRUNING.

The Wichuraiana and hardy climbing roses should be pruned just after blooming. At this time young shoots will have started from the roots. The growth of these shoots should be encouraged, as it is from them that most of the branches are produced that bear the following year's bloom. The best way is to remove all the old wood at this time, so that all the strength will go into the young shoots. Where the roses are trained over a trellis so high that one season's growth will not cover it, the method just described is not practicable. In such cases some of the old shoots should be cut off at the ground, and the others should be shortened from 3 to 6 feet, depending on the amount of growth the vine has been making each year. New shoots should be trained to take the place of those removed. It should be kept constantly in mind that the present year's growth bears next year's flowering branches and that a few vigorous branches are more desirable than many weak ones.

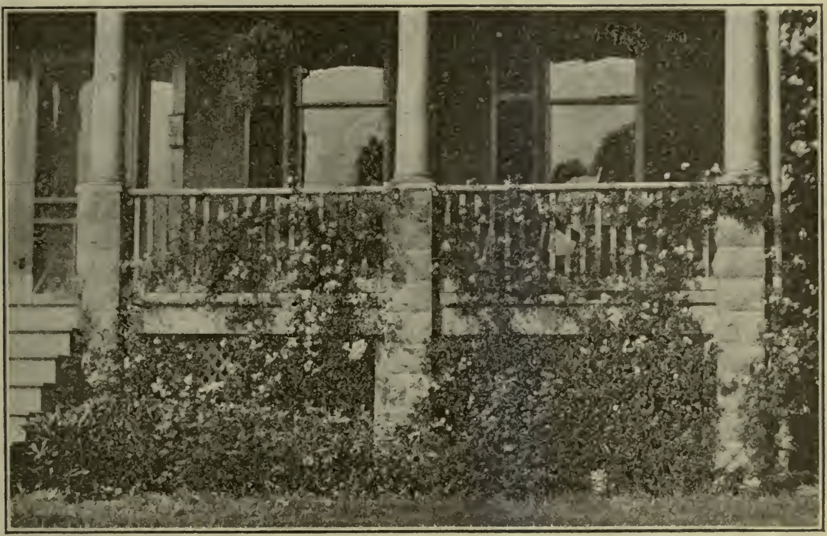
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FIG. 7.—Dorothy Perkins roses in bloom. The left-hand panel shows the same bushes illustrated in figure 6 as they appeared later.

In the spring any weak branches may be removed, and the ends of some of the others may be shortened, but comparatively little should be taken off. Figure 6 shows climbing roses after the spring pruning. The left-hand panel of figure 7 shows the same roses in bloom, while figure 8 shows the same plants 6 weeks after blooming, all the wood shown in figure 6 having been cut away as soon as the blooms faded. The wood seen in figure 8 is of the current season's growth. Most of the blooms on the Multiflora and Wichuraiana roses and their hybrids will be on the shoots from the last year's wood, and every bud removed reduces the number of blooms. This method of pruning removes most of the foliage just after blooming and leaves the trellises without covering during the hottest part of the summer.

Roses of the hybrid Noisette group, of which the Marechal Niel is a representative, should be trained to a good strong cane, with the side shoots cut back to about three eyes. The main cane can be renewed occasionally.

The Cherokee rose should be treated like the border roses, pruning only dying or crossing branches. Every few years it may be cut back severely and allowed to start again.

Roses are not climbing plants in the same sense as grapevines or morning-glories. They have no tendrils and do not support themselves by twining. For this reason it is necessary to train and tie the canes as they grow.

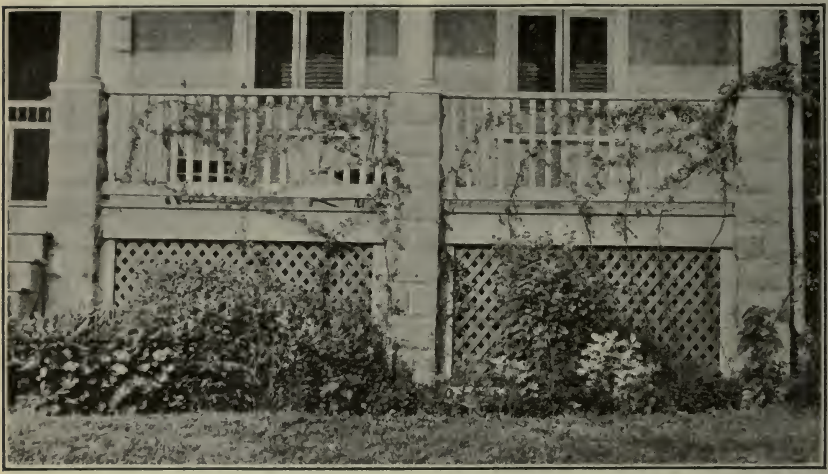

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FIG. 8.—The same roses shown in figures 6 and 7 after the blooming season. All the bent stems seen in figure 6 and all the flowering wood seen in figure 7 have been removed, and what is shown here is the young growth made the current season.

PROTECTION.

In the northern sections, where roses are apt to winterkill, it is necessary to protect climbing roses in some way. Wrapping the bushes in straw is effective where the cold is not too great, but is somewhat unsightly. It permits keeping the vines more nearly in their summer position. A surer method is to lay the vines down, covering them with earth, and after that is frozen adding a layer of straw or manure. This covering must be removed promptly in the spring as soon as freezing is over.

ROSES FOR CUTTING.

Roses for cut flowers require special attention and care to be successful. Their appropriate place is in the flower garden or in a secluded bed of their own, as shown in figure 9. They need more room and more cultivation than plants adapted to border planting. For ease of cultivation, for accessibility in gathering blooms, and for effectiveness in treating insect and fungous attacks, it is desirable that these roses be grouped in beds specially arranged for them. Like other flowers designed primarily for cutting, they have an important place on the home lot, but that place is in a special garden or in a subordinate place in the general planting scheme, and they should not be used for lawn planting.

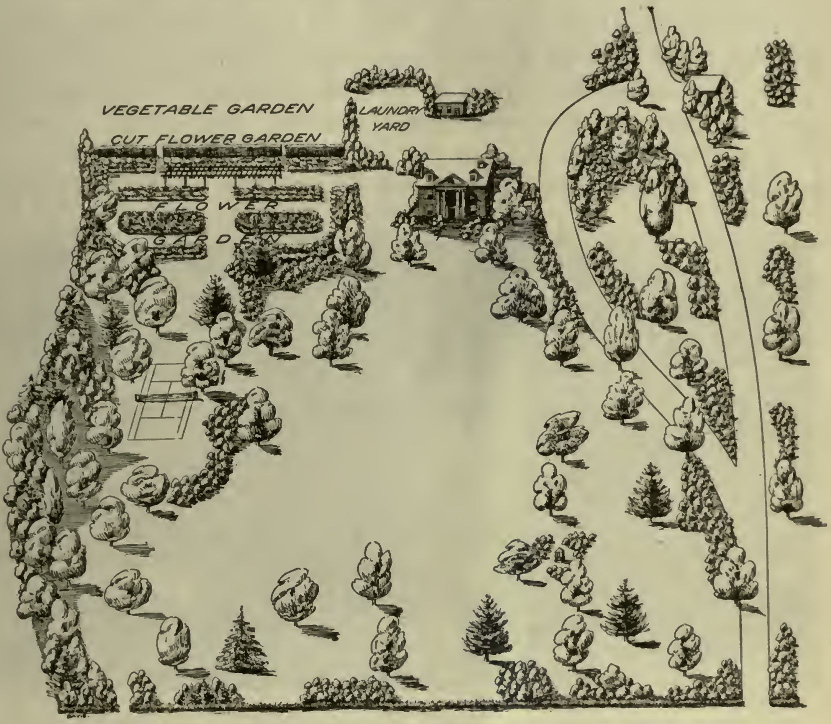

FIG. 9.—Farm home grounds, typical of suburban homes. Border roses would be appropriate with other shrubs in any of the clumps indicated, either near the house or along the borders of the lawns. Cut-flower roses would be appropriate either in the flower garden or in the cut-flower garden by the side of the vegetable garden.

VARIETIES.

Hybrid perpetuals, hybrid teas, teas, Bengals, Bourbons, and Chinas are the roses available for cut flowers. There is a multitude of varieties, so that everyone should be able to find some to his liking.

The hybrid perpetual roses (fig. 10) usually bloom only in the early summer, but sometimes bloom a second time if thoroughly pruned, especially if given a midsummer check by dry weather. They are the hardiest of the cut-flower roses and are the only ones to be relied upon in the colder parts of the country and in the rural districts of the dry-land region. The map (fig. 11) indicates the region where these roses are the most useful. In the warmer sections with plenty of moisture the hybrid teas are more desirable.

The hybrid tea roses (fig. 12), when properly treated, bloom from spring until cold weather. Many of the varieties succeed north of the area marked for them. They will succeed on the southern portions of the Great Plains if they can be irrigated, but are not adapted to the sections of that region where irrigation is not available.

Tea roses are tenderer than hybrid teas. Although some of them are weak growers, they are most attractive. One writer describes them as "the spoiled child of the rose family." The tea roses succeed well in the South Atlantic and Gulf States and on the Pacific coast. These and the hybrid teas provide the most satisfactory roses in the regions where they succeed.

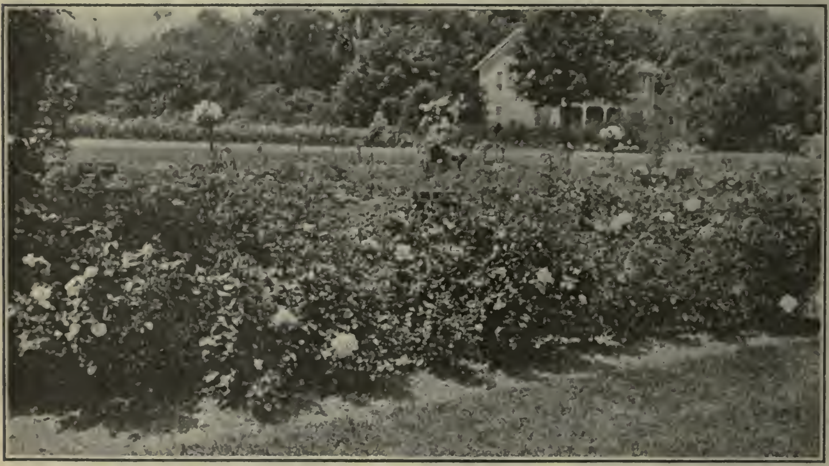

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FIG. 10.—A bed of hybrid perpetual roses (Frau Karl Druschki).

The China or Bengal rose is one of the forms from which a great many of the garden roses have been developed. But few of these varieties are now offered by nurserymen.

The Bourbon rose is best known through the variety Souvenir de la Malmaison, which in hardiness compares favorably with the hybrid teas. There are other varieties.

The selection of varieties is best made after consultation with near-by growers or nurserymen who are most familiar with local conditions. The larger rose-growing firms are also in a position to make reasonably safe suggestions for any region if given full information as to location, exposure, kind of soil, and other local factors.

THE KIND OF STOCK TO PLANT.

Nurserymen speak of roses as "own root," "budded," or "grafted." By own-root roses they usually mean a rose that has been grown from a cutting, though roses grown from seed are as truly own-root roses as those grown from cuttings. As opposed to own-root roses there are budded or grafted roses, which means that a single-leaf bud or a stick with one or more buds of one kind has been made to grow on the roots of another kind. The plant that provides the roots is called the stock, and the one that provides the top, whether bud or graft, is called the scion. In nature, roses are propagated mostly from seed, and many of the cultivated rose species may be freely grown in that way. In the less improved species all the plants will be very much alike. In the more improved species the variations may be very marked. An improved species in this sense is one which has been cultivated for generations, and even centuries, from the seedlings of which man has selected those that have most appealed to him. In many cases those selected have been the result of crosses with other species. These extreme and unusual types will not propagate true from seed, and must, therefore, be propagated from cut-

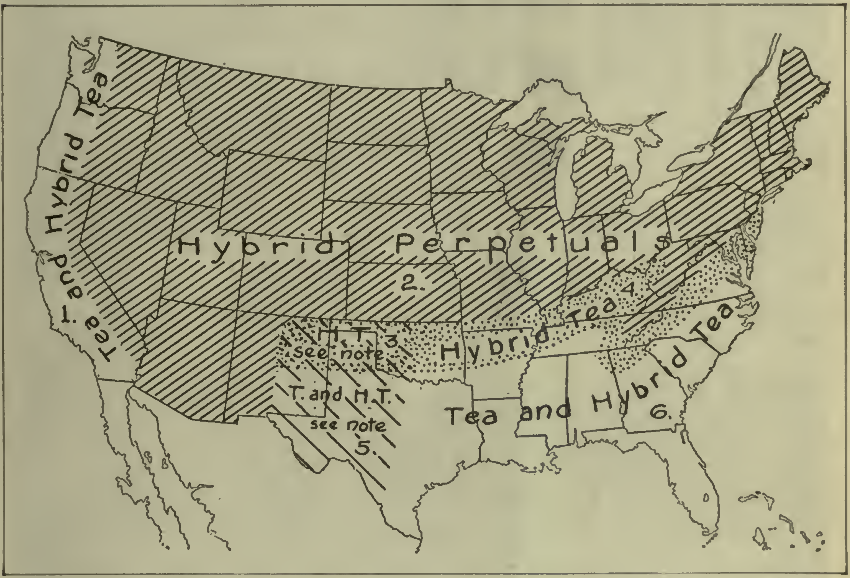

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FIG. 11.—Outline map of the United States, showing the classes of roses best adapted for cut-flower purposes in the different sections: 1, Teas and hybrid teas; 2, hybrid perpetuals; 3, hybrid teas and hybrid perpetuals, possibly even some hardy teas where there is plenty of water for irrigation (where they can not be irrigated hybrid perpetuals are best); 4, hybrid teas and hybrid perpetuals, possibly even some hardy teas; 5, hybrid perpetuals (where there is ample water for irrigation teas and hybrid teas may be used, as in section 6); 6, teas and hybrid teas.

tings or by buds or grafts. In each case some wood from the old plant is taken to make the new one. When wood is plenty and the rose grows vigorously, cuttage is the natural method to use. When wood is scarce, or the variety is a weak grower, or has a poor root system, or its own roots are not adapted to the soil on which it is to be grown, budding or grafting is used. Budding takes the least wood and is so satisfactory that it is most used.

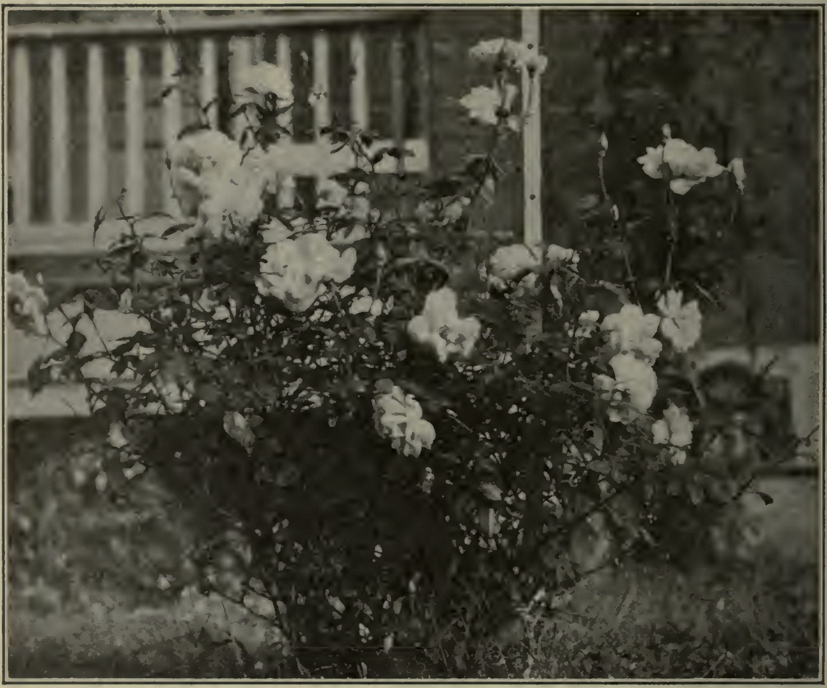

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FIG. 12.—A hybrid tea rose (White Maman Cochet).

For the roots or stocks on which to graft or bud other roses an easily propagated strong-growing variety is needed. It must be easily propagated to provide a large number of plants cheaply. It must be a vigorous grower in order to provide ample nourishment for the new top. On the other hand, it must not be so vigorous as to have an excessive tendency to push out suckers below the graft or bud and thus rob the adopted top of its proper nourishment.

The advantage of grafted and budded roses is that they are more vigorous the first few years, but they have to be watched closely to prevent shoots starting from the stock, as such shoots take the sap and thus starve the scion. The expert who can constantly watch his plants may be successful with grafted and budded roses, but the average grower would do best to use own-rooted plants, even though they do not grow so fast. The few varieties that succeed only when grafted should not be tried until the grower has become expert in handling roses. Climbing roses are grafted less often than hybrid perpetuals, hybrid teas, and teas.

Plants are propagated under glass and in the field. The field-grown plants are usually rather more robust and more likely to withstand adverse conditions. The older pot-grown plants offered by nurserymen are frequently field-grown plants potted and forced for spring sales. Such plants, if well handled, are as good as the unforced stock where potted material is needed. This is very different material from that grown almost exclusively under glass. The pot-grown plants are desirable whenever spring planting must be delayed beyond the usual planting season. For fall planting and for early spring before corn-planting time dormant field-grown plants should be used.

The size or age of the plant to use is largely a matter of choice. They are offered in various sizes, from 1 to 3 years. These ages are reckoned from the time when the cutting was made or the time when the budding or grafting was done. The plants from cuttings are smaller than the other plants of the same age and variety. Three-year-old plants give the quickest results. Two-year-old plants can be transplanted more successfully than older ones and are rather more satisfactory. One-year-old plants have to be grown for a year before any real results are obtained in the way of bloom. The first year the flower buds should be picked from this small size as soon as formed, to let all the strength go into growth.

SOIL AND DRAINAGE.

Cut-flower roses thrive in a well-drained soil that is not too dry and is well supplied with organic matter. The hybrid perpetuals succeed best in clay loam or in a soil with a clay subsoil. They do not succeed so well in gravel soils. Many of the tea roses and their hybrids succeed in very light lands if well supplied with organic matter and water, although the ideal soil is a loamy one. A well-enriched soil and one reasonably constant in its ability to supply the plant with moisture is the chief requirement. On the other hand, it must be well drained, as roses will not grow when water stands about their roots. In heavy clay soils or wherever water is liable to stand, it is desirable to provide artificial drainage. This is best done by excavating to a depth of 3 feet, placing a 12-inch layer of stones in the bottom, covering these with inverted sods, and then refilling the bed with well-prepared soil (fig. 13). This layer of drainage should be connected with some proper outlet for carrying off the water. A drain of a similar layer of stones 1 foot or more wide, or a tile, should lead to some main drain, a sewer, or to an opening on lower land, so that surplus water will be carried away immediately. In well-drained soils such special precaution is not necessary. Sometimes the layer of stones without the outlet drain will be sufficient.

The recommendations already made about manures and fertilizers are equally applicable to cut-flower roses. The use of rotted cow manure or well-prepared compost is even more important for cut-flower roses than for border roses.

PLANTING.

The time of planting cut-flower roses varies with the kind of plants, the location, and somewhat with the season. These roses are supplied by dealers either as dormant or as potted plants. Through those sections where the temperature does not fall below 10° F., where the winter winds are not exceptionally drying, and where the soil has been so prepared that it does not heave badly, dormant roses are best planted in the fall. In other places spring planting is best. Directions for planting dormant roses are given under "Roses for the lawn and border." If budded or grafted roses are used they must be planted deeper than own-root roses would be, as shown in figure 14. Because of the liability of shoots starting from the stock below the scion, the point of union between the stock and scion should be planted 3 inches under ground. By planting in this way the scion will have an opportunity to form roots from the part of the stem in the ground and thus become at least partially own rooted. Planting the stock so deeply discourages the formation of new shoots from it. If any appear they must be removed at once.

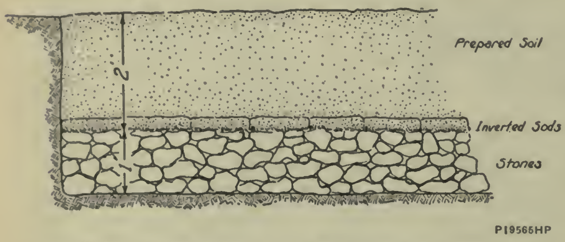

FIG. 13.—Cross section of a well-prepared rose bed.

Potted plants should be set out only in the spring after the maples come into leaf, or not over two weeks before the oaks come into leaf. With potted plants, no root pruning is necessary, as any pruning required should be done at the time of potting. Where the roses are small and suited to the size of the pot, the balls of earth are planted with the top half an inch or so below the surface. The soil is compacted about the ball without breaking it. These roses are watered in the same way as dormant plants.

Field-grown plants, especially the larger sizes, usually have long roots. When placed in a pot of a practicable size these roots are doubled up. In planting them in the garden the roots should be straightened out. One advantage of pot-grown plants is to have plants whose roots are in close contact with the soil, so they will continue their growth without interruption. To disturb the ball of soil in straightening the roots is liable to break this contact. By having the ball of earth quite wet, its breakage does not cause the complete dropping away of the soil when it is disturbed for the purpose of spreading the roots. Good earth must be well compacted about these soil-covered roots, and the whole should be watered and dry soil put about the plants after the water has soaked away.

Hybrid perpetual roses should be set from 2 to 3 feet apart, depending on the vigor of growth and the locality. In the regions indicated on the map (fig. 11) as having to depend mostly on these roses for cut flowers, 30 inches is probably far enough apart when they are pruned for individual blossoms. When the greatest mass of bloom is wanted the vigorous ones had better be 3 feet apart. When used in the South they should be slightly farther apart, but because most of them bloom only once during the season, or at most only in the spring and fall, they are neglected there in favor of kinds more desirable for the region.

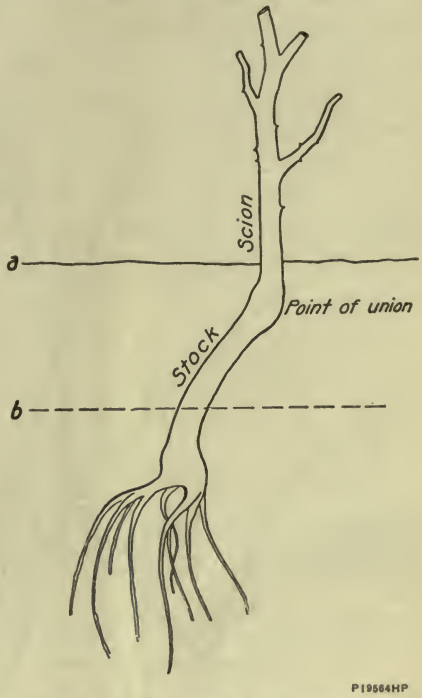

FIG. 14.—Proper depths for planting roses: *a*, Proper soil level for a grafted or budded rose; *b*, proper soil level if the plant were on its own roots.

Tea roses should be planted from 18 to 30 inches apart, depending on the vigor of growth and proposed treatment, 18 to 24 inches probably being about right for cut flowers.

The hybrid tea roses have a greater range of character of growth even than the other kinds discussed, and the proper distance for planting corresponds. The planting distance is from 20 inches to 3 feet, being greatest in the warmer regions where they get an abundance of water and least where they are retarded in growth by cold winters or dry summers.

The China and Bourbon roses should be planted about as far apart as the hybrid perpetuals.

CULTIVATION.

Cut-flower roses should have the ground entirely to themselves. They should not be planted among other plants nor have other plants between them, not even pansies or other low-growing herbs. They need clean cultivation throughout the season every year. If room permits and a large number of roses are being grown, they can be more economically handled by being planted in rows sufficiently far apart for horse cultivation. Cultivation should begin early and continue till within six weeks of the dormant season.

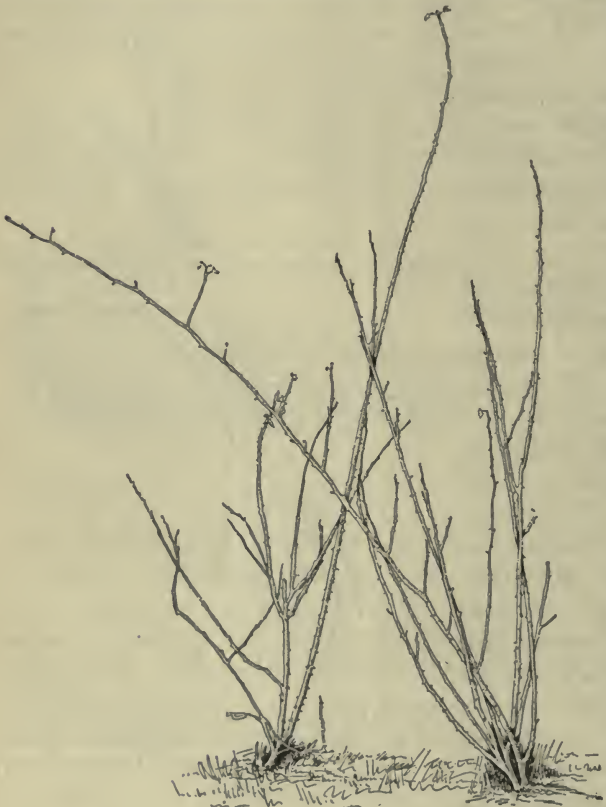

FIG. 15.—Unpruned hybrid perpetual roses: Gloire de la Exposition Bruxelles (at right) and Frau Karl Druschki (at left).

At the first cultivation in spring the manure of the winter mulch should be worked into the soil, or a good coating of manure should be specially applied if there is no mulch. The first working should be deep, to incorporate the manure with the soil. The later cultivations should be just deep enough to maintain a surface mulch.

PRUNING.

For the production of individual blossoms of greatest perfection, as well as to secure a succession of bloom, severe pruning must be practiced. When a large number of blooms of small size is the aim, the pruning is less severe. Where the greatest amount of bloom is desired, without regard to the size or quality of the individual flowers, the least pruning is done. When dormant cut-flower roses are set in the fall one-half or more of the wood should be removed, as directed for planting the species used for ornamental groups. In the spring these roses should be cut back more, leaving only two or three stems with four or five eyes on each. This will leave them 6 inches or less in length. When dormant roses are planted in the spring they should be pruned at the time of planting, leaving four or five eyes on a stem, as above recommended. In regions where there is no danger of injury from frost or dry winds, the final pruning, as described for spring, may be made in the fall.

After the first year, pruning should be done as soon as freezing weather is over. In regions where roses never suffer from cold it may be done in the fall. All weak wood and crossing branches should be removed every year. For fine specimen blooms on hybrid perpetuals the remaining shoots should be shortened to four or five eyes. Figure 15 shows unpruned hybrid perpetuals and figure 16 the same bushes pruned for individual blooms. For the greatest mass of bloom only one-third to one-half the length of the shoots should be cut away.

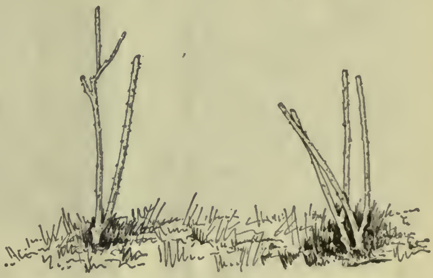

FIG. 16.—Hybrid perpetual roses pruned for individual blooms. These are the same bushes that are shown in figure 15.

In regions where cold sometimes injures roses, teas and their hybrids should be trimmed later than the other classes, or about the time growth starts. They should be trimmed in the same manner as the hybrid perpetuals, but because of their usually more delicate growth they will look much smaller when the work is done. The strongest growing roses should not be cut as short as the weaker ones. When overpruned the tendency of the plants is to growth rather than to bloom, and a few varieties will not stand the extremely close pruning described. When pruned for specimen blooms the teas and hybrid teas will be only 6 inches to 1 foot high. Figure 17 shows an unpruned hybrid tea, while figure 18 shows the same bush pruned for individual blooms. China, Bengal, and moss roses should be treated the same as the teas and hybrid teas, except that it is not desirable to cut them quite so closely. Bourbon roses should have only half the length of the shoots removed. Summer pruning is desirable.

When a flower is cut from a tea rose or other perpetual bloomer, only two or three strong eyes of the current season's growth of that branch should be left on the plant. This should give the roses very long stems. Figure 19 is the same plant shown in figure 18 as it appeared the next June. Two flowers were cut from this bush three days before the picture was taken. The remaining flowers should be cut close to the ground, where the foliage hides the stems. It will seem like destroying the bush to take so much off, but if the object is the production of roses, the cutting away of the surplus wood will attain the desired end. If the spring pruning has not been sufficiently severe, the plant is liable to have the characteristics shown in figure 20, long, naked stalks and short stems to the flowers. With this character of growth only one or two strong leaf buds should be left on the branch when the flower is cut, so as to stimulate as much growth as possible from the base of the plant.

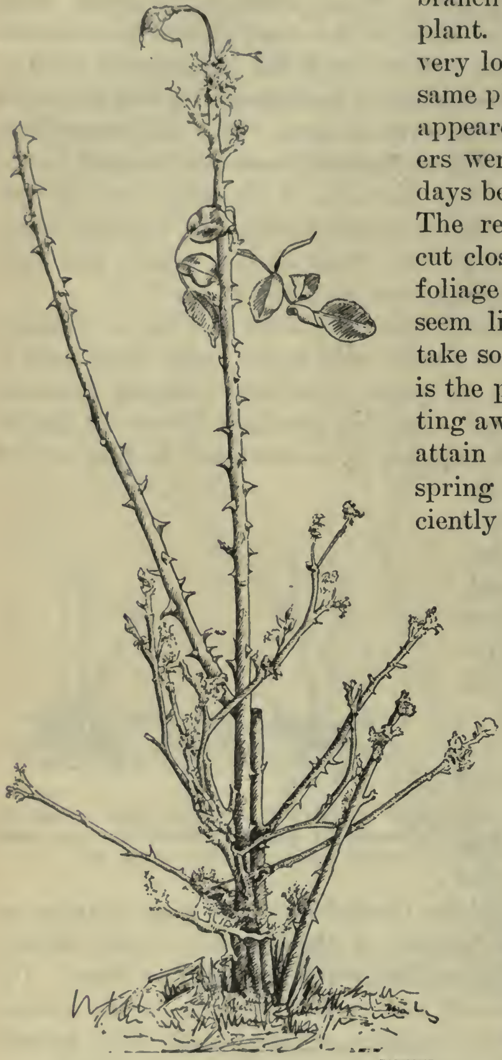

FIG. 17.—A hybrid tea rose (Radiance) before pruning.

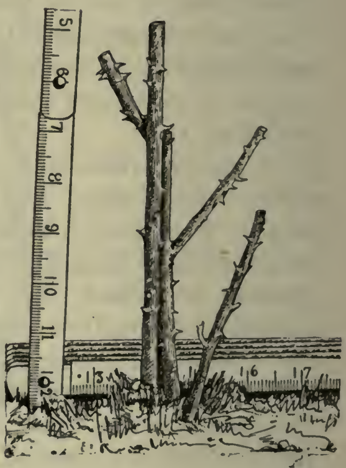

FIG. 18.—A hybrid tea rose (Radiance) after pruning for individual blooms. This is the same bush that is shown in figure 17. It would be better to cut the left-hand shoot even shorter.

The greatest temptation to leave wood is where there are two or more buds on one branch, some being small when the terminal one is open. This temptation to follow a bad practice can be avoided by pinching off all side shoots after a bud has formed on the end of a branch. This prevents the formation of two or more buds on one stalk. This summer pruning will encourage additional blooms on varieties which bloom more than once a year.

Where winter protection is necessary, it is desirable to cut back the tops in the fall to within 30 inches of the ground to allow of more easily covering the bushes. This should be followed in the spring by the regular pruning. The long stems left in this fall pruning help hold the winter mulch from blowing away and from packing too closely. They are also long enough to allow considerable winterkilling and yet have sufficient eyes left to insure ample growth for the next season's bloom.

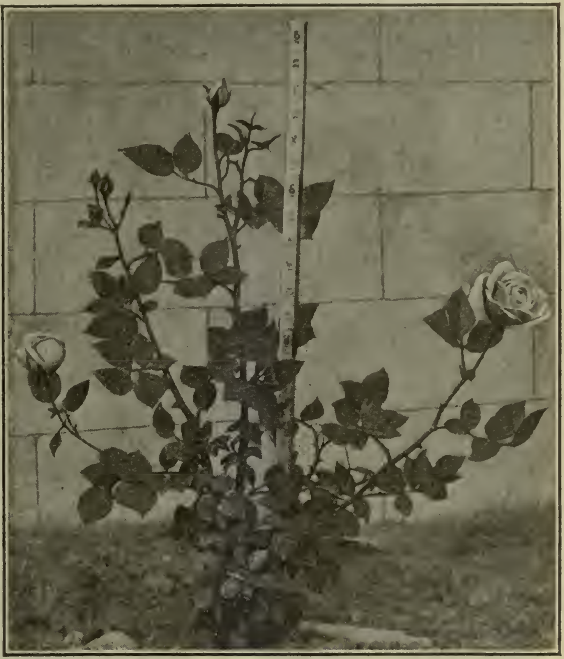

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FIG. 19.—The same rose that is shown in figures 17 and 18, at blooming time. Two blooms were cut from this bush three days before this picture was taken. The remaining blooms should be cut under the foliage where the stems are hidden.

PROTECTION.

The cut-flower roses need winter protection in the northern half of the country. This may be provided by coarse manure, straw, or leaves applied after the preparatory pruning already described. Evergreen boughs, or even branches from deciduous plants, are often helpful in holding the other materials in place, besides being a protection in themselves. Individual specimens are often wrapped in straw or straw and burlap. There is some danger of trouble from mice in the use of straw and strawy manure, especially during hard winters. This is minimized by banking earth about the plants before mulching.

This banking of earth is also a most effective prevention of injury from cold. Earth banked up about the plants to a height of a foot or more makes an excellent protection, especially if covered well with manure after the ground first freezes. The earth cover must be promptly removed in early spring, as soon as danger from freezing is past.

These roses thrive best when not exposed to strong winds. For that reason it is desirable that they be protected. Shrubbery borders, evergreen plantations, and sometimes even fences covered by roses or other vines will make a satisfactory windbreak.

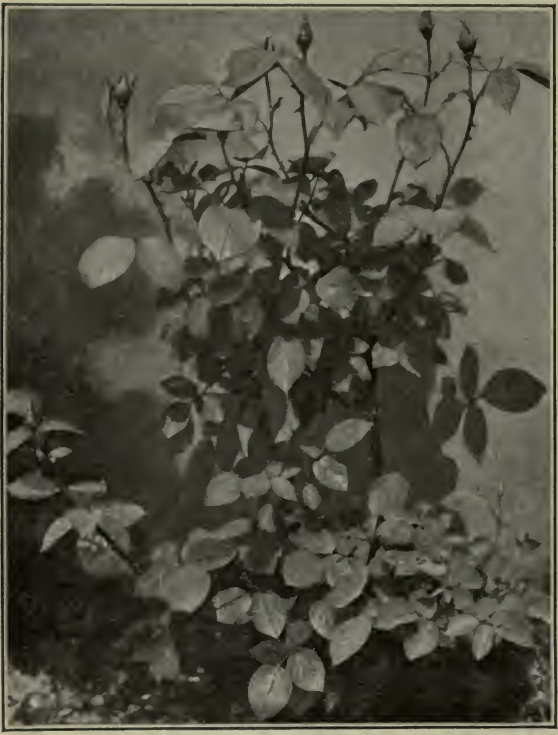
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FIG. 20.—A hybrid tea rose (Killarney) on which the stems were left too long in pruning.

SPECIAL CARE.

Where roses have but a short winter check, due to mild weather, and are grown under irrigation a part of the year, it is conducive to better results to check their growth in the dry season for a month or six weeks by drying them and forcing them to rest.

Where growth is not satisfactory and some plants do not seem to take hold as well as others, the application of a diluted liquid manure often stimulates and starts a plant to growing well.

ROSES FOR OTHER ORNAMENTAL PURPOSES.

HEDGES.

Roses are sometimes desired as a hedge, but are not so well adapted to this purpose as many other plants. Climbing roses make an excellent cover for a fence, as shown in figure 21. The brier roses make a good hedge if severely and frequently pruned, but most roses are neither sufficiently compact nor sufficiently branched to make a really good hedge. The Rugosa rose (fig. 22) makes a handsome summer barrier, but is so poorly branched that even in summer it does not give protection against small animals, and in winter it does not have a hedge-like appearance. It may be found that some of the untried rose species will be valuable for this purpose.

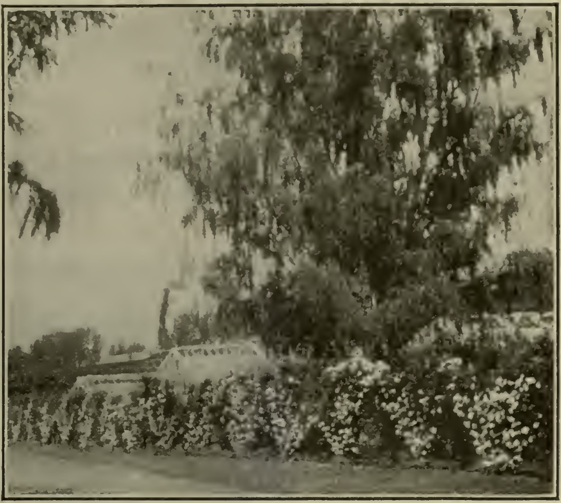

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FIG. 21.—A fence covered with climbing roses (Tausendschoen and Philadelphia Rambler in alternation). The most pleasing effect is usually obtained by using a single variety of rose for decoration of this sort.

Hedges need to be closely pruned. This is probably best done twice a year, in the winter or spring and again after flowering time, pruning severely for outline and compactness.

Most so-called rose hedges are rows of cut-flower roses, usually pruned for mass of bloom, with little of the appearance of a hedge except at the height of bloom. Where a few weeks' appearance of barriers is all that is needed, hybrid perpetual and hybrid tea roses may be used as well as other species for this purpose.

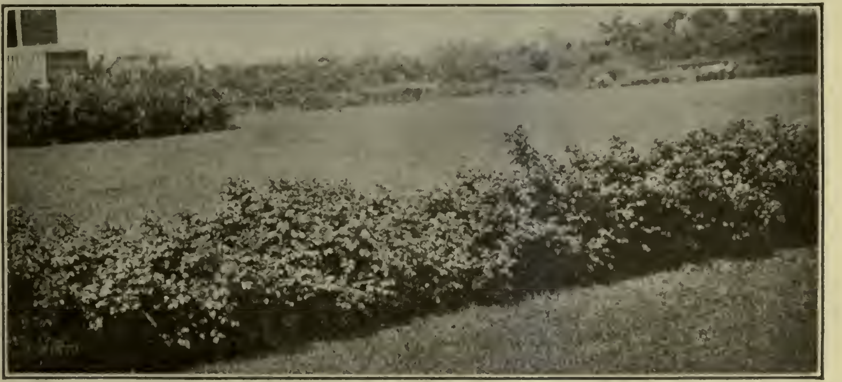

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FIG. 22.—A hedge of Rugosa roses.

The hedge should be planted in a trench 3 feet wide and 2 feet deep, filled with soil prepared as for a bed of cut-flower roses.

GROUND COVERS.

As already stated, *Rosa lucida* can be used for covering poor banks with foliage to a depth of 2 or 3 feet, and *Rosa nitida* grows to a height of only 18 inches. The Wichuraiana, already mentioned as a climbing rose, is a trailing rose when given an opportunity and makes a beautiful almost evergreen ground cover (fig. 23), with small, glossy, dark-green leaves. It is useful for banks, as shown in figure 24, the sides of steps, or for hanging over rock cliffs or retaining walls. When permitted to trail it mats closely and roots at every joint. Some training but little pruning is needed when it is used in this way.

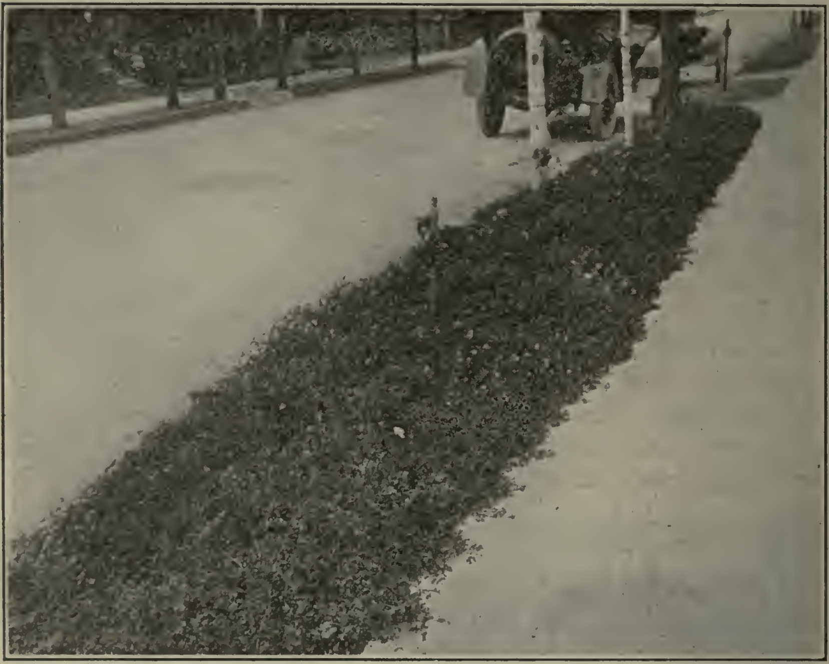

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FIG. 23.—Wichuraiana roses used as a ground cover in a parking space.

TREE ROSES.

A tree rose (fig. 25) is a bush rose grafted 3 or more feet above the ground on a long, straight stalk of a brier, Rugosa, or other strong-stemmed rose. These bushes are not very satisfactory in the United States, because the stocks now available do not seem able to stand the hot sun and hot drying winds of the climate of most of this country. In western Oregon and western Washington they succeed. Their appropriate use is only in connection with a formal design, either in special gardens or near buildings.

CULTURAL PRACTICES.

PROPAGATION.

Roses are propagated from seed, by hardwood cuttings, softwood cuttings, layers, budding, and grafting.

The rose species used as shrubs, such as the Rugosa, Carolina, Prairie, and Wichuraiana, are propagated by root sprouts and the others named by hardwood cuttings. The Wichuraiana is naturally a trailing plant which takes root near any eye. By cutting rooted stems into pieces so that each one has some roots and an eye each one will make a plant.

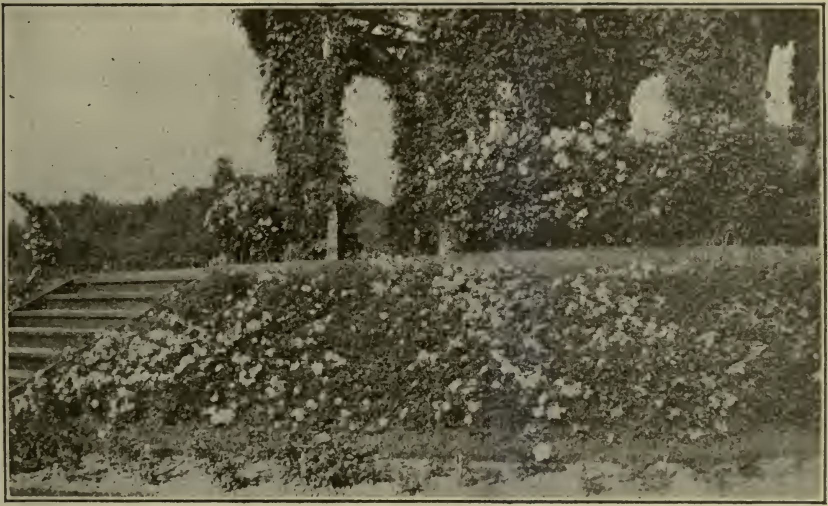

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FIG. 24.—A bank covered by Wichuraiana (Memorial) roses, with Rugosa roses against the summerhouse in the background.

Some rose species, like *Rosa hugonis*, are difficult to grow from cuttings and are therefore grown by layering; that is, by covering shoots with earth until they are well rooted before cutting them from the plant. The rooted stems of the Wichuraiana might be considered to be natural layers.

Climbing roses are mostly propagated by hardwood cuttings. Cut-flower roses are grown from hardwood cuttings, greenwood or softwood cuttings, and by budding or grafting.

Hardwood cuttings are taken from the dormant wood of winter, while softwood, or greenwood, cuttings are taken when the plants are in active growth. To make a hardwood cutting, good, strong, well-ripened shoots of the past summer's growth should be selected. These are better if cut between the time the leaves fall and freezing weather. If left until after cold weather there is danger of injury from freezing. They should be cut into pieces of 5 or 6 inches, with the upper cut just above a bud, and should be tied in bundles with raffia or with string that does not rot easily if exposed to dampness. After labeling plainly they should be buried in moist sand, tops down, and placed in a cool cellar or buried in the open ground below danger of frost. They should be planted in the open ground in the spring about or a little before corn-planting time, so that one or two eyes, or not over 1 inch of the cutting, is above the ground, which will leave 4 or 5 inches in the ground. Care must be taken not to injure the calluses that have formed while the cuttings were buried. Sometimes better results are obtained by planting in partial shade.

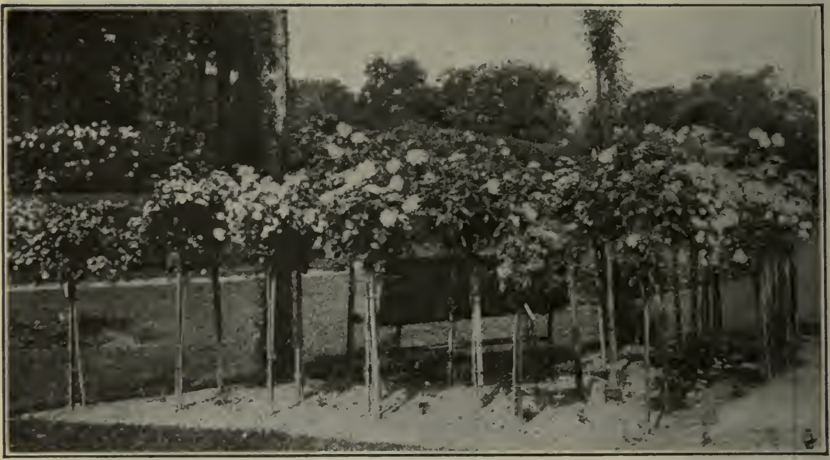

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FIG. 25.—Tree roses. Not very satisfactory in the climate of the United States.

Frequently cuttings made in winter or early spring do nearly as well as those made in the fall, but in the North there is always danger of the wood being injured during the winter.

Softwood, or greenwood, cuttings (fig. 26) are made soon after blooming, from wood of the current year's growth. This may be taken from the stems that have grown roses or those that have not. There are claims that it makes a difference which sort of shoot is used, but good, strong shoots are the most important consideration. These should be cut to three eyes. All the leaves should be removed except the top one, and all the leaflets should be removed from this except parts of two. These cuttings may or may not be made with a "heel," which in this sense is a piece of older wood at the bottom of the cutting. The cuttings should be planted at once in light loamy soil or in sand in a bed where the atmosphere may be inclosed. A coldframe or spent hotbed is a suitable place if the glass is shaded or a cheesecloth frame is used instead of the sash. For a few cuttings many people have success by inverting over them a fruit jar (fig. 27) or a glass dish. The cuttings, however, need to be shielded from the direct rays of the sun when under glass, to prevent burning. The object of the inclosed atmosphere is to prevent undue evaporation from the leaves before roots have formed sufficiently to support the plant. When roots have freely formed, the plants should be transplanted to good soil, watered well, and shaded for a few days from the midday sun. Subsequent watering should be moderate until they are well established.

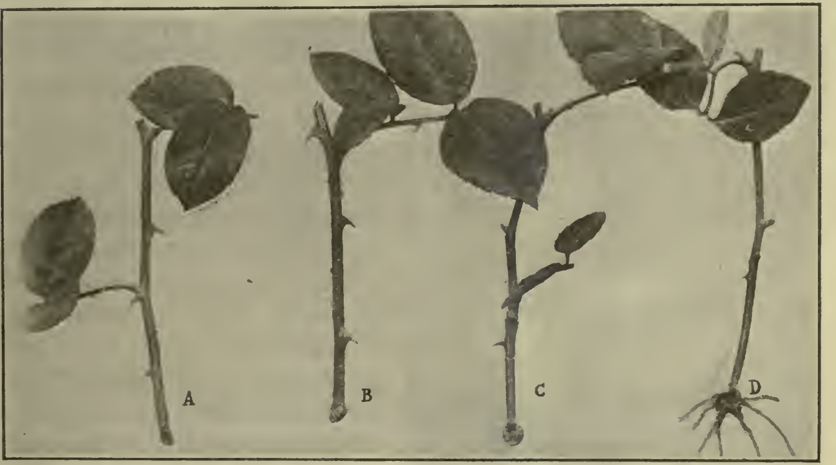

FIG. 26.—Rose cuttings: *A*, First made; *B*, partially callused; *C*, callused; *D*, roots starting.

Budding and grafting are not necessary in order to get satisfactory results in growing roses either about the farm home or on the city lot; therefore, space will not be taken here to describe the methods employed.[1]

INSECT REMEDIES.[2]

Insects which most commonly affect roses are of two general types, those which eat the foliage, as rose slugs and the rose chafer, and those which suck the sap, as aphids, scale insects, and thrips.

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[1] For methods of budding and grafting, see U. S. Dept. of Agr., Farmers' Bulletin 157, entitled "The propagation of plants."

[2] The matter relating to insect remedies was reviewed in the Branch of Forest Insects, Bureau of Entomology, which investigates insects affecting hardy shrubs, including roses, to whom inquiries about them should be addressed.

The presence of leaf-eating insects is usually first detected through the discovery of partially eaten leaves or of skeletonized leaves; that is, leaves from which a portion of the lower or upper surface has been eaten, leaving the other surface as a transparent membrane, or leaves the fleshy part of which has been eaten clear through, often leaving merely the midrib and veins. The discovery of the enemy frequently follows. Protection from this sort of attack is afforded by hand picking or by covering both surfaces of the foliage thoroughly with some poisonous substance, as arsenate of lead. Wherever a garden hose is available, a strong stream of water directed against rose slugs on the foliage will knock them off and, in many cases, save the bush from further injury by them. The rose chafer is a rather difficult insect to control, and arsenical poisons applied at double the usual strength often fail to kill them before the damage is done. Frequent hand picking of the beetles and dropping them into a vessel containing water covered with a film of kerosene, or screening the plants with mosquito netting, especially the latter, often affords the only means of preventing their destructive work.[1]

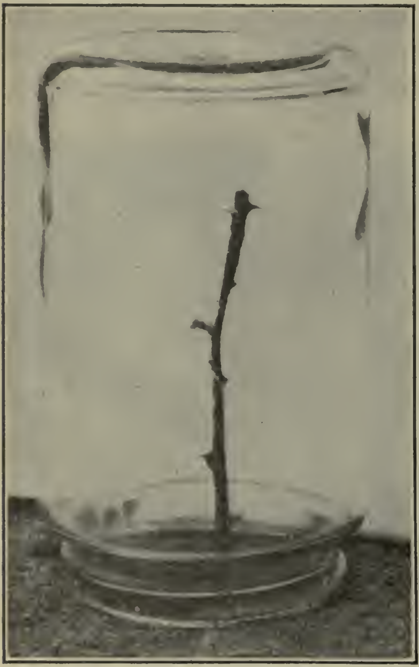
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FIG. 27.—Rooting a hardwood rose cutting under a fruit jar. This protection is even more necessary for greenwood than for hardwood cuttings.

Arsenate of lead, the substance usually most available as a spray against leaf-eating insects, is a deadly poison. It is procurable in most seed stores as a white paste, or powder, and should be used at the rate of about one-eighth of a pound of the paste or one-sixteenth of a pound of the powder to 10 quarts of water.

Sucking insects obtain their food by sucking the sap. Aphids are usually on the youngest growth at the tips of the branches, both on the stems and on the under side of the leaves. When badly infested, the leaves curl and protect the insects on their under surface. Thrips injure the flowers, while scale insects usually inhabit the woody portion of the bush and are capable of killing it. Insects of this class have to be killed by the insecticide coming in contact with them. Materials used for this purpose are 40 per cent nicotine sulphate, pyrethrum, fish-oil soap, kerosene emulsion, and lime-sulphur. The material should be applied in a fine spray, with considerable force, so as to find its way under the foliage and strike the culprit. Death comes from the insecticide closing the breathing pores and suffocating the insect or penetrating to its vital parts, or both. Great thoroughness is needed in applying these insecticides. The aphids may often be knocked off by a strong stream of water from a hose where available, and this treatment, frequently given, is often all that is necessary to keep them in check. An abundance of ants on the plants is always suggestive of the presence of aphids.

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[1] For fuller information on the habits and control of the rose chafer, see Farmers' Bulletin 721.

Forty per cent nicotine sulphate, a liquid procurable in most seed stores under various proprietary names, diluted with about 1,000 parts of water in which a little fish-oil soap or good laundry soap has been previously dissolved, is now recognized as the most efficient aphid remedy. For small quantities, add 1 teaspoonful of the nicotine to each 1 or 2 gallons of water in which about one-half an ounce of soap has been dissolved. One thorough application is usually 100 per cent effective, though a second spraying may sometimes be necessary. The necessity of covering every individual insect should be constantly borne in mind.

Pyrethrum, known also as buhach or Persian insect powder, may be used at the rate of 1 ounce to 2 quarts of water. This is much more effective when fresh.

Fish-oil soap may be dissolved at the rate of one-fourth of a pound to 8 quarts of water. It dissolves most quickly in hot water. A small quantity of hot water may be used first and then the solution diluted to the quantity mentioned. It should be cooled before it is applied.

Kerosene emulsion may be prepared as follows: Dissolve 1 ounce of good laundry soap in 1 pint of hot water; remove from the fire, add 1 quart of kerosene, and beat until a creamy mixture is formed, from which the oil does not separate, but which becomes semisolid on cooling. To pump it back into itself by means of the spray pump is an efficient method of emulsifying the mixture. This emulsion should be reasonably permanent and may be kept as a stock solution. For applying, use 1 pint of the stock solution to 10 quarts of water.

Commercially prepared insecticides, like lime-sulphur, should be used according to the directions accompanying them. There are many good brands on the market.

DISEASES OF ROSES.

Mrs. Flora W. Patterson, Mycologist of the Bureau of Plant Industry, contributes the following on the subject of the fungous diseases of roses:

Fungous parasites.—Roses are rarely killed outright by fungous parasites, but by their presence the vigor of plants is greatly reduced, the foliage may be rendered unsightly, branches become more or less distorted or disfigured, and the quality of the blossoms lowered. In considering the fungous diseases of these plants the fact must be recognized that in common with similar diseases of other plants treatments are preventive rather than curative. While thorough and repeated sprayings with a suitable fungicide will in most cases so check the development of the parasite that the disease for the growing season will be in a great measure controlled, the full benefit of fungicidal applications can only be secured by their early use in the spring, guarding in this way against the recurrence of a disease of the previous season.

Fungicides to be recommended for rose diseases are Bordeaux mixture, lime-sulphur, potassium sulphid, and ammoniacal solution of copper carbonate. The lime-sulphur has proved very valuable, especially in controlling mildew, as it does not injure the foliage of even delicate tea roses.

Powdery mildew.—Powdery mildew is extremely common, few gardens being entirely free from this most destructive of all rose diseases. Wild as well as cultivated roses suffer from it, crimson ramblers being especially susceptible. There is, however, a wide difference in the susceptibility of different varieties, as well as in the susceptibility of the same variety in different localities. Each rose grower should give special attention to the degrees of resistance shown by the various sorts in his collection, keeping only those which show the greatest resistance to the disease.

The fungus frequently appears very early in the season on young buds, leaves, and young shoots. It causes the appearance of a delicate white mildew that becomes mealy after the development of the conidia, or summer spores.[1] If the attack is severe, the normal development of the succulent young shoots is arrested, the leaves become curled and deformed, falling prematurely, and complete defoliation sometimes results. Later in the season on twigs, calyx, fruit, and even on canes the fungous mycelium[2] forms a whitish, feltlike covering on which minute spherical black bodies are borne and in which the winter spores develop. These spores are capable of persisting through the winter and setting up a new infection in the spring.

The stage of the disease in which the summer spores are produced in immense numbers may be held under control by several treatments with a fungicide applied very thoroughly at intervals of 10 days to a fortnight. For this purpose dusting with flowers of sulphur is frequently recommended, but spraying with a solution of either lime-sulphur or potassium sulphid is better. If the development of the parasite has not been completely arrested in its summer stage and if the winter spores have been permitted to develop, more energetic measures must be taken. Late in the fall diseased portions of the bushes should be trimmed off and burned, together with all fallen leaves and débris that have collected under the bushes. The plants should then be thoroughly sprayed with lime-sulphur or strong Bordeaux mixture, allowing the surrounding soil to become drenched.

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[1] Microscopic bodies which serve to reproduce the fungus.

[2] Microscopic threadlike growth of the fungus.

Rose rusts.—The diseases known as rusts are caused by any one of several parasitic fungi, and they occur on both wild and cultivated bushes. Any part of the plant may suffer from the presence of the fungus, but the effect produced varies with the time of year and the part attacked. In the spring or early summer on the green parts of the bush conspicuous orange-colored swellings appear that later in the season take on a deeper shade and become powdery. On the leaves the effect may be shown by small circular spots, but when the swellings occur on young, green stems and petioles those parts become bent and greatly distorted. During these stages of growth the parasite has borne two kinds of spores, but later a third kind, the winter spores, develop either in small black groups on the under surface of the leaf or in more or less elongated black powdery patches on the woody stems.

The spread of the disease in its early stages can be checked by spraying several times with ammoniacal copper carbonate, but it is advisable first to cut off the infected parts. Late in the autumn all infected material must be cut away and burned and the bush thoroughly sprayed with strong Bordeaux mixture. If the bushes continue to suffer for two or three seasons from rust, they might well be dug up and burned, for the fungus is capable of living over the winter in apparently healthy stems and may be a source of continuous trouble.

Anthracnose.—Anthracnose is caused by a fungus which attacks all parts of the bushes, but the young growth is most susceptible. On the leaves appear blotches that contain the fruiting bodies and later become pinkish from the escaping spores. Upon the surface of the branches similar fruiting bodies form and, bursting, discharge a pinkish mass of spores. These fruiting bodies may entirely surround the branch and spread toward its tip. The leaves upon such a branch are dwarfed and pale and soon fall. The complete defoliation of the bush may follow a severe attack. During the growing season the disease may be fairly well controlled by spraying several times with Bordeaux mixture or ammoniacal copper carbonate. Later, all diseased branches must be rigorously cut back and together with the fallen leaves carefully raked up and burned and the bushes thoroughly treated with strong Bordeaux mixture.

Leaf-spot.—There are several distinct diseases that are called leaf-spots, and each is caused by a different fungus, but the effects of these parasites upon the leaves are very similar, and such attacks are seldom serious. The spots have a more or less brownish center with a purplish border.

The spread of these troubles may be checked by spraying with Bordeaux mixture or the solution of ammoniacal copper carbonate, but it is well also to pick off as many as possible of the spotted leaves and burn them.

Leaf-blotch.—Leaf-blotch, also known as black-spot, is probably the most common and injurious of all fungous diseases to which the rose is subject except powdery mildew. Many species suffer from it, but certain varieties are immune to the disease, and if it is troublesome in a garden it will be well to cultivate the resistant varieties. Bush roses are more susceptible to this trouble than climbing roses, and attacks are most severe in wet seasons. The first symptoms of the presence of the parasite are irregularly shaped blackish spots without definite borders on the upper surface of mature or nearly full-grown leaves. These spots may grow together so as to cover almost the entire leaf. In this stage the trouble may be controlled by several applications of Bordeaux mixture or ammoniacal copper carbonate, but if permitted to remain untreated another spore-producing form develops in the same spots. This second form matures upon decaying fallen leaves, and its spores living over the winter are able to set up a new infection in the spring. This fact shows the necessity of raking up and burning the fallen leaves, as well as the advisability of drenching the ground under the bushes both then and in the early spring with strong Bordeaux mixture. It is well to begin the spring treatments with ammoniacal copper carbonate on plants that have suffered during the preceding season, without waiting for the spots to appear.

Canker.—Canker has recently become in some localities the cause of serious trouble, and unfortunately no absolutely certain method of treatment has been worked out. The early symptoms of canker are the appearance of small reddish patches on the green parts, generally of 1-year-old growth. The disease is caused by a fungus classed as a wound parasite, that is, the spores gain entrance to the bush through certain mechanical injuries. These may be slight ones made upon the young branches by the thorns of the bush itself when one branch has been blown against another, or by insect punctures. Such infected areas may increase until the entire stem is surrounded and may extend for several inches along the branch.

The only advice to be given is to rigorously cut away all diseased branches, and it may be necessary to cut back entire bushes if badly infected. Cover the exposed surfaces made by this cutting with paint or tar. This diseased material must be burned and the dormant bushes sprayed with strong Bordeaux mixture in both the autumn and early spring. At the first appearance of the disease, cut away and destroy all the branches showing infection. Then spray about every 10 days, first with Bordeaux mixture and later with ammoniacal copper carbonate, as spraying has no disfiguring effect upon the foliage, an appearance to be avoided when blossoming time is near. It is possible that by such careful attention the bushes may outgrow the disease.

FUNGICIDES FOR ROSE DISEASES.[1]

Bordeaux mixture.—Bordeaux mixture is the best all-round fungicide, but it will stain the foliage and other objects with which it comes in contact a blue-green color. Wooden or earthen containers should be used in mixing this spray. If metal containers are used both the containers and the spray may be ruined.

The following formula for Bordeaux mixture is recommended for summer spraying: Copper sulphate (bluestone), 2½ ounces; lime (unslaked), 2½ ounces; water to make 2 gallons.

For spraying dormant plants reduce the quantity of water used in making up the spray from 2 gallons to 1½ gallons.

Mix the copper sulphate with nearly half of the water, being sure that it is thoroughly dissolved. Slake the lime with a little water, to make a smooth paste, then add most of the rest of the water to the paste, making a uniform solution of milk of lime. Pour these two solutions at the same time into a vessel containing the remainder of the water, and, after thoroughly stirring, strain the mixture. If properly made, the mixture will have a sky-blue color, and it should be used promptly. The two solutions, however, may be kept indefinitely before being poured together.

To make the liquid adhere to the plants an ounce of any good mild soap for each gallon of mixture should be dissolved in a little hot water and added to the mixture.

Potassium sulphid.[2]—Potassium sulphid for home use may be made according to the following formula: Potassium sulphid (liver of sulphur), 1 ounce; water,

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[1] For more detailed information, see U. S. Dept. of Agr., Farmers' Bulletin 243, entitled "Fungicides and their use in preventing diseases of fruits."

[2] Metal containers should not be used in mixing this spray.

3 gallons. The addition of 1 ounce of any good mild soap to each gallon of the solution of these ingredients is recommended to make the liquid adhere to the plants.

Lime-sulphur.—Commercial lime-sulphur has directions for its use upon the container and can be purchased from seedsmen and hardware firms handling farm implements, or it may be made at home as for spraying fruit trees. It is one of the best of fungicides. Care must be used in applying it near buildings, as it spots paint badly. It is injurious to the clothing and is caustic in its action on the skin. Cold cream or vaseline used in liberal quantities will serve as a protection.

Ammoniacal copper carbonate.—The ammoniacal spray is difficult to prepare and requires caution in handling and application. It should not be employed unless the discoloration caused by the other sprays is seriously objectionable. Wooden or earthen containers, not metal, should be used in handling it.

The following formula is suggested for making ammoniacal carbonate of copper: Copper carbonate, one-fourth ounce; strong ammonia (26° Baumé), about one-half gill; water, 2 gallons.

Dilute the ammonia with a little of the water and dissolve the copper carbonate in it, using only barely enough ammonia to dissolve the carbonate; if necessary, reserve a little of the carbonate until the rest has been dissolved, and then add the remainder. No more of the ammonia than enough to dissolve the carbonate should be used under any circumstances. The clear blue liquid may then be diluted with the remainder of the water, and, if properly made, it does not become cloudy as it is diluted.

SPRAYING.

To make effective application of the remedies for the control of insects and diseases, the materials must be applied to all parts of the plant. This is best done by the use of a fine spray applied till the foliage is wet, but not so wet that the liquid collects into drops.

To do good work, it is not only necessary to use a pump that has power sufficient to produce a very fine spray, but the nozzle needs to be connected with the tank by a hose, so that it may be turned in any direction, and the outlet should be at an angle of 45° to the supporting tube, so as to facilitate throwing the spray on the under side of the leaves as well as on top. This is necessary because many insects and diseases attack from below as well as from above. In order to meet these conditions a very large or expensive outfit is not essential, but the capacity of the nozzle should be adjusted to the power of the pump. For a few roses, a gloved thumb and finger to crush the attacking insects, a coarse cotton bag to apply dry powders, and a pair of scissors to clip off diseased leaves on their first appearance, will produce satisfactory results with a real rosarian, that is, with one who so loves roses that he almost unconsciously inspects them several times a day. Any one living on a place large enough to require the use of a shovel and hoe should have a 3-gallon or 5-gallon spray outfit, whether he has any roses or not, as there are but few plants grown that do not need the insurance afforded by the judicious use of such an implement.

SUMMARY.

Roses may be divided into classes according to the purposes for which they are used, as for lawns and borders, for arbors or trellises, for cut flowers, and for other ornamental purposes.

Native species and those least modified by man's crossing and selection are most suitable for lawn and border planting.

Climbing roses used for arbors and trellises may be handled either to give an abundance of bloom or to produce shade, but they can not do both satisfactorily, and they are not as well adapted to the production of shade as many other plants.

Cut-flower roses need clean culture, severe pruning, and special care; therefore, they should be planted by themselves in secluded beds and should not be used to beautify the grounds in place of the roses appropriate for lawns and borders.

Roses are not very satisfactory for hedges.

The Wichuraiana rose is useful as a ground cover.

Tree roses are not satisfactory, except in the Pacific Northwest.

The essentials for successful growth are a well-drained retentive soil thoroughly enriched, preferably with rotted manure. Cut-flower roses especially need heavy annual manuring.

Special care must be exercised to prevent the roots from drying when out of the ground for transplanting.

Own-rooted plants are best for the average grower.

Cut-flower roses need protection near the northern limits of the successful cultivation of the variety.

Dormant roses should have one-half to two-thirds of the wood removed at the time of transplanting.

Border roses should have little pruning, the removal of the dead wood and the cutting of the whole bush to the ground every 5 to 8 years being best for most varieties.

Climbing roses should be pruned just after blooming by having the wood of the previous year's growth removed.

Cut-flower roses should be cut each spring to within 6 inches or 1 foot of the ground for finest blooms, or one-third to one-half the wood should be left for the greatest quantity of bloom.

Watchfulness is the price of success with roses, especially with the climbing and the cut-flower varieties.

Advice as to varieties for a particular region is best obtained from the nearest grower or nurseryman.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 191

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS.

FARMERS' BULLETINS
Nos. 726-750,

WITH CONTENTS AND INDEX.

PREPARED UNDER THE SUPERVISION OF
JOS. A. ARNOLD,
EDITOR AND CHIEF.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1918.

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